National Park Service
U.S. Department of the Interior

Northeast Region
Boston, Massachusetts

Northeast Coastal and Barrier Network Vital Signs Monitoring Plan

Technical Report NPS/NER/NRTR--2005/025

ON THE COVER
Cape Cod National Seashore Salt Marsh in Fall
Photograph by: courtesy of Cape Cod National Seashore

Northeast Coastal and Barrier Network Vital Signs Monitoring Plan

Technical Report NPS/NER/NRTR--2005/025

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October 2005

U.S. Department of the Interior
National Park Service
Northeast Region
Boston, Massachusetts

The Northeast Region of the National Park Service (NPS) comprises national parks and related areas in 13 New England and Mid-Atlantic states. The diversity of parks and their resources are reflected in their designations as national parks, seashores, historic sites, recreation areas, military parks, memorials, and rivers and trails. Biological, physical, and social science research results, natural resource inventory and monitoring data, scientific literature reviews, bibliographies, and proceedings of technical workshops and conferences related to these park units are disseminated through the NPS/NER Technical Report (NRTR) and Natural Resources Report (NRR) series. The reports are a continuation of series with previous acronyms of NPS/PHSO, NPS/MAR, NPS/BSO-RNR and NPS/NERBOST. Individual parks may also disseminate information through their own report series.

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Please cite this publication as:

Stevens, S., B. Milstead, M. Albert, G. Entsminger. September 2005. Northeast Coastal and Barrier Network Vital Signs Monitoring Plan. Technical Report NPS/NER/NRTR--2005/025. National Park Service. Boston, Massachusetts.

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Introduction and Background

The Northeast Coastal and Barrier Network (NCBN) is one of 32 networks created by the National Park Service to implement ecological monitoring activities under the NPS Vital Signs monitoring program. The NCBN consists of eight parks linked by geography and shared natural resource characteristics. These parks extend along the Northeastern Atlantic Coast and include Assateague Island National Seashore (ASIS) in Maryland and Virginia, Thomas Stone National Historic Site (THST) in Maryland, Cape Cod National Seashore (CACO) in Massachusetts, Gateway National Recreation Area (GATE) in New York and New Jersey, Fire Island National Seashore (FIIS) and Sagamore Hill National Historic Site (SAHI) in New York, and Colonial National Historical Park (COLO) and George Washington Birthplace National Monument (GEWA) in Virginia.

These eight parks together contain approximately 59,220 hectares (146,300 acres) of park lands, representing some of the most ecologically similar collections of lands within the National Park Service. They consist of critical coastal habitat for many rare and endangered species, as well as migratory corridors for birds, sea turtles, and marine mammals. These parks protect vital coastal wetlands that are essential to water quality, fisheries, and the biological diversity of coastal, near shore, and terrestrial environments.

The NCBN monitoring program will enable us to better understand the condition of park ecosystems while providing reference points for comparisons with other altered environments. This report describes in detail how the Network selected what to monitor, how those things will be monitored, in what parks and when. Following is a brief summary of each monitoring chapter within the plan.

Conceptual Models

The NCBN has created conceptual models to guide the development of its monitoring program. Conceptual models provide a unifying framework for integrated, interdisciplinary monitoring. They are especially effective in network-wide, multi-park programs where the interactions among ecosystems within a group of parks are complex and difficult to interpret.

A conceptual model identifies and links interactions and describes primary relationships among external activities or processes that influence the ecosystem. They help us to recognize problems and products of human activities or natural events that alter the quality or integrity of the ecosystem. These models are detailed in Chapter 2.

Vital Signs

The intent of the National Park Service Vital Signs Monitoring Program is to track a subset of physical, chemical, and biological elements and processes of park ecosystems called “vital signs”. The elements and processes that will be monitored as part of the

NCBN Vital Signs Program, are only a subset of the total suite that could be monitored to provide NCBN park managers with better data and information to make scientifically based management decisions. The Network has prioritized 18 vital signs placed in the following five categories: *estuarine eutrophication; salt marsh change; geomorphologic change; visitor use and impacts; and landscape change*. Protocols are being developed to monitor these vital signs over the long-term in network parks.

Sampling Design

NCBN will carefully develop statistical sampling designs that will be integrated across protocols and parks. Details of the sampling design for the Network's draft protocols are described in Chapter 4. Each monitoring protocol follows a specific sampling design that is consistent with National Inventory and Monitoring Program guidelines. Key to the success of any monitoring program, the sampling design associated with each NCBN protocol will undergo rigorous peer and statistical review before monitoring is implemented.

Monitoring Protocols

Ten monitoring protocols are scheduled to be developed through the NCBN Vital Signs Program (Chapter 5). Each protocol includes a detailed *narrative* that contains a summary of its history–from protocol design through development, including policies or decisions that are relevant to the protocol. This will allow the protocol to develop more efficiently and ensure that it will not be a repetition of previous trials or comparisons (Oakley *et al.* 2003). The narrative will include a list and brief summary of all *Standard Operating Procedures* (SOPs), which are developed in detail as independent sections in each protocol.

Monitoring protocols consist of:

1. justification for vital sign selection
2. monitoring goal, questions and objectives
3. sampling design (including spatial and temporal sample design)
4. field methods
5. data management
6. data analysis and reporting
7. staffing requirements
8. training procedures operational requirements

Data Management

To develop and maintain high quality data, the NCBN has created an Information Management Plan that describes its information and data management infrastructure (e.g., staffing, hardware, software) and architecture (databases, procedures, archives). This plan includes procedures to ensure that monitoring data collected as part of the NCBN Vital Signs monitoring program are entered, quality-checked, analyzed, reported, archived, documented, cataloged, and made available for management decision-making, research, and education.

In addition, the NCBN is developing specification and guidance documents to share with park, network, regional, and national staff. These guidelines describe methods for managing natural resource information from hard copy reports to digital photos. The NCBN Standard Operating Procedures (SOPs) will describe in detail how to create FGDC compliant metadata and conduct quality control procedures on collected data.

Data Analysis and Reporting

Reports are the primary means of communicating the work of the Network's vital signs monitoring projects. Five types of reports will be produced on a regular basis by the NCBN vital signs monitoring program: (1) Annual Administrative Report and Work Plan, (2) Annual Protocol Reports, (3) Protocol Trend Reports, and (4) Program and Protocol Review Reports and (5) Condition Assessment reports. The content of each of these reports and the frequency and schedules for Protocol Trend Reports and Program and Protocol Review Reports is described in Chapter 7.

Fort Wadsworth, Gateway National Recreation Area, Staten Island Unit, New York

Administration/Implementation of the Monitoring Program

The NCBN has developed a long-term plan for administering and implementing its monitoring program. It is accountable to the eight network parks through a Board of Directors and through direct cooperation with park management and staff. Technical oversight is provided by the Network's Technical Steering Committee.

As a result of the changing dynamics involved in developing a monitoring program, the NCBN will reassess and modify the staffing plan as needed, once the final monitoring plan is approved and implementation begins. To maintain flexibility during the transition from planning to implementation, the plan relies heavily on contract, seasonal, and term employees. Some of these positions will be converted to permanent NPS positions once the long term program and project needs have been validated.

Schedule

The NCBN has determined a schedule for developing and implementing each protocol. Four draft monitoring protocols have been completed: Ocean Shoreline Position, Salt Marsh Nekton, Salt Marsh Vegetation, and Estuarine Eutrophication. Six additional protocols are in development and will be completed over the next three years (2008). Chapter 9 of this plan provides a full protocol development and implementation schedule. Annual protocol reports and trend reports will be completed for each monitoring protocol. In addition, every six years the overall NCBN program and all of the monitoring protocols will be reviewed and a summary report produced.

Acknowledgements

Many people have contributed to the development of this monitoring plan. In particular, all of our network resource management staff contributed time and effort to laying the groundwork for this monitoring program and provided direction and feedback throughout the planning process. Natural Resource Management staff at each of the Network parks: Nancy Finley, Cape Cod NS; Chuck Rafkind, Colonial NHP; Carl Zimmerman, Assateague Island NS; Rijk Morawe, Thomas Stone NHS and George Washington Birthplace NM; Scott Gurney, Sagamore Hill NHS; Mike Bilecki, Fire Island NS; and Gateway NRA staff, George Frame, Doug Adamo, Dave Avrin, and Bruce Lane, have all provided much needed assistance over these first five years. Many of our resource managers sit on the Technical Steering Committee and will continue to assist us as the program continues to grow.

We would also like to thank the many other individuals at the network parks, such as administrators, program analysts, maintenance who have provided information, participated in meetings and workshops or helped in countless other ways. Gateway staff was so generous in providing space and technical assistance for two Network meetings, the Network Scoping Workshop in 2000 and a workshop on Visitor Impacts in 2005. Thanks again to the parks for providing housing to Network staff for meetings and field seasons. Thanks to all of the Inventory and Monitoring Staff who are part of the Cape Cod NS prototype monitoring program, especially Nancy Finley, Carrie Phillips, Bob Cook, John Portnoy and Velma Decker for their assistance and collaboration on protocol and database development and review. The prototype program at Cape Cod NS has provided the Network with a solid foundation only due to the team developing the program.

We would especially like to thank Beth Johnson, the Northeast Region Inventory and Monitoring Coordinator, who provided the early guidance and oversight for the program, building awareness and support among superintendents, establishing the Science Committee and hiring positions. She continues to support the Network acting as a Board member as well as a Technical Committee member. Stationed with the Network at the University of Rhode Island, she provides guidance to us on a daily basis.

We thank the Board of Directors who play a very important role in assisting the network with decision making and advice. Members of the Board of Directors provide valuable support, advice and advocacy. Because of their involvement, the network will become integrated into park management and relevant to resource-related decisions.

Thanks to all of the Northeast Region Science staff, especially chief regional scientists, John Karish and Mary Foley. Administrative support has been provided over the past five years by Carol Daye. We thank Carol for her assistance to the Network, including handling agreements, contracts, budgeting and payroll. We also thank the University of Rhode Island, Department of Natural Resources Science-especially Dr. Peter Paton, Dr. Tom Husband and Dr. Peter August-for hosting and assisting the NCBN in establishing our presence at the University. Thanks to Chuck Labash of the University of Rhode Island's Environmental Data Center for providing project and technical assistance. Chuck has spent a tremendous number of hours hiring, supervising and assisting staff working on Network projects, as well as assisting Network staff in general. Linda Fabre, a member of the Environmental Data Center has done an incredible job of creating species databases for all of our parks, as well as many other tasks. Her dedication, commitment and support of the Network is so valued. We'd like to thank Dennis Skidds, also part of the Environmental Data Center, for completing a multitude of projects for us, as well as Scott Tiffney who has been in charge of populating the bibliographic database, NatureBib, for the Network.

Scott, Linda and Dennis play an important role in the Network's data management program.

Thanks to the members of the Network's Technical Steering Committee for their sound advice and contributions to several vital signs meetings and workshops. We would also like to thank all of our cooperators who have spent a considerable amount of time developing and testing protocols for the Network. In particular, Hilary Neckles, Blaine Kopp, Charles Roman, Mary-Jane James Pirri, Norb Psuty, Jeff Pace, Yu-Fai Leung, Christopher Monz, Y.Q. Wang, Mike Traber, John Brock, and Wayne Wright.

Mark Duffy, a Network staff member, in charge of developing the geomorphologic vital signs and protocols, has been key in handling and developing this important part of the Network's program. Mark has worked extremely hard on this effort and we would like to thank him for his dedication to these projects.

Finally, we would like to send out thanks to Theresa Moore of the Northeast Temperate Network for her assistance with layout, design, and editing of this plan.

Chapter 1 Introduction and Background

Introduction

National Park Service (NPS) managers are mandated to preserve and protect natural resources in parks for future generations. They must be able to evaluate current management and restoration practices as well as anticipate future threats. Managers must be able to recognize changes and trends in the condition of resources in their parks. In order to accomplish these tasks efficiently and effectively, managers must have reliable information about these resources.

To address the need for reliable, scientifically founded information, the National Park Service has implemented a strategy to design and implement natural resource inventory and monitoring. The effort was undertaken to ensure that 270 park units with significant natural resources, possess the resource information needed for effective, science-based managerial decision-making and resource protection. The national strategy, called the Inventory and Monitoring Program (I&M), includes three major components: (1) completion of basic resource inventories upon which monitoring efforts can be based; (2) creation of experimental Prototype Monitoring Programs to evaluate alternative monitoring designs and strategies; and (3) implementation of operational monitoring of critical parameters (i.e. "vital signs") in all parks with significant natural resources.

Vital Signs, as defined by the NPS I&M Program, are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a representative subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," (NPS Organic Act 1916) including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

The Northeast Coastal and Barrier Network (NCBN), one of the 32 networks organized to share funding and a core professional staff, is composed of eight parks linked by geography and shared natural resource characteristics (Table 1.1). These parks extend along the Northeastern Atlantic Coast (Figure 1.1) and include Assateague Island National Seashore (ASIS) located in Maryland/Virginia, Thomas Stone National Historic Site (THST) located in Maryland, Cape Cod National Seashore (CACO) in Massachusetts, Gateway National Recreation Area (GATE) located in New York and New Jersey, Fire Island National Seashore (FIIS) and Sagamore Hill National Historic Site (SAHI) located in New York, and Colonial National Historical Park (COLO) and George Washington Birthplace National Monument (GEWA) both located in Virginia. Together, these eight parks contain approximately 59,220 hectares (146,300 acres) of park lands, representing some of the most ecologically similar collections of lands within the National Park Service. They consist of critical coastal habitat for many rare and endangered species, as well as migratory corridors for birds, sea turtles, and marine mammals. They also protect vital coastal wetlands, essential to water quality, fisheries, and the biological diversity of coastal, near shore, and terrestrial environments. For detailed descriptions of NCBN parks, see NCBN 2004a.

Because they are part of the Atlantic coastline, NCBN parks represent islands of protected lands within the urban sprawl of the Northeast. Sixteen percent of the United States population resides in the coastal zone

Table 1.1. Northeast Coastal and Barrier Network Park Members.

Park Name	Code	State	Hectares	Acreage
Assateague Island National Seashore	ASIS	MD,VA	19,200	48,000
Cape Cod National Seashore	CACO	MA	17,442	43,604
Gateway National Recreation Area	GATE	NY, NJ	10,644	26,610
Fire Island National Seashore	FIIS	NY	7,832	19,580
Colonial National Historical Park	COLO	VA	3,740	9,350
George Washington Birthplace NM	GEWA	VA	220	550
Thomas Stone National Historic Site	THST	MD	129	322
Sagamore Hill National Historic Site	SAHI	NY	33	83

(Culliton *et al*. 1990), 25% of the nation's population resides in the Northeast Region. Census estimates indicate that populations within this zone are growing three times faster than the United States population (Culliton *et al*. 1989). Thus, it will become increasingly important to understand how urban pressure affects these park ecosystems.

This document describes the planning process as well as the implementation plan for vital signs monitoring in NCBN parks.

Justification for Integrated Natural Resource Monitoring

Knowing the condition of natural resources in national parks is fundamental to the NPS's ability to manage park resources. National park managers are confronted with increasingly complex and challenging issues that require a broad-based understanding of the status and trends in condition of park resources. A broad-based understanding is necessary for making decisions and for working with other agencies and the public. For years, managers and scientists have sought a way to characterize and determine trends in the condition of parks and other protected areas. Managers need to determine the efficacy of management practices and restoration efforts, and they need to have early warning of impending threats. Since most parks are open systems, the challenge of protecting and managing a park's natural resources hinges on a partnership-based, ecosystem-wide approach. Threats, such as air and water pollution or invasive species, often originate outside of a park's boundaries. In these cases, understanding and managing resources may require a local, regional, national, or international effort.

Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making intended to maintain, enhance, or restore the ecological integrity of park ecosystems, while avoiding, minimizing, and mitigating ecological threats to these systems (Roman and Barrett 1999). Natural resource monitoring provides site-specific information needed to understand and identify changes in complex, variable, and imperfectly understood natural systems. Monitoring provides a basis for understanding and identifying *meaningful change* in natural systems characterized by complexity, variability, and surprises. By using monitoring data, we can define the normal limits of natural variation in

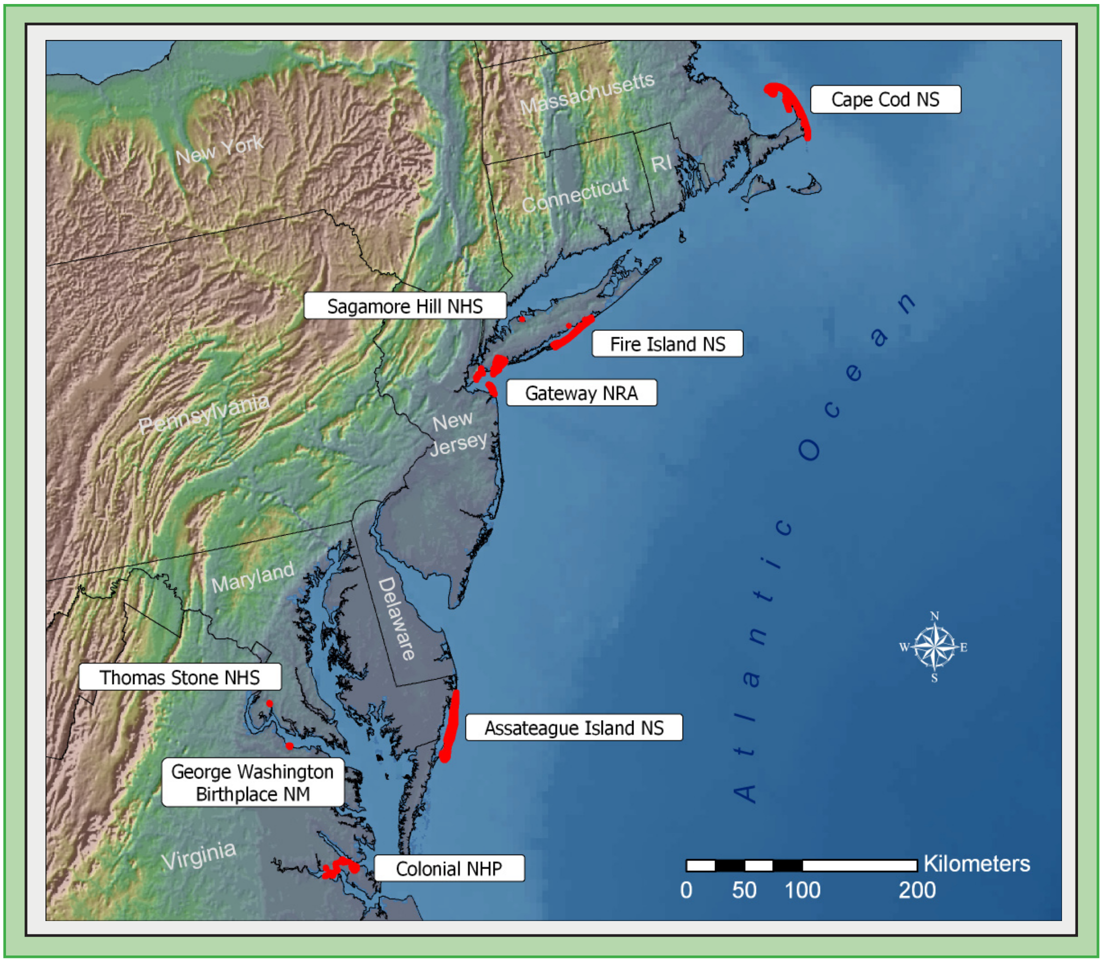

Figure 1.1. Map of the eight Northeast Coastal and Barrier Network Parks (Cape Cod National Seashore (CACO); Sagamore Hill National Historic Sites (SAHI); Fire Island National Seashore (FIIS); Gateway National Recreation Area (GATE); Assateague Island National Seashore (ASIS); Thomas Stone National Historic Site (THST); George Washington Birthplace National Monument (GEWA); Colonial National Historical Park (COLO)).

park resources and provide a basis for understanding observed changes. The information we obtain from monitoring may also be useful in determining what constitutes impairment and in identifying the need to initiate or change management practices.

Federal Legislation, Policy, and Guidance

Although not stated in the early policies of the National Park Service, current United States Federal law and National Park Service policies direct national park managers to know the status and trends in the condition of natural resources under their stewardship. Even though the mission of the National Park Service, according to the NPS Organic Act, 1916, states that the National Park Service must "… *conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations,*" it wasn't until the amendment of the Organic Act in 1978 that Congress strengthened the protective function of the National Park Service to add language important to recent decisions about resource impairment, *"The protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been* *established….”*

More recently, the National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management processes of the National Park System. This Act charges the Secretary of the Interior to “*continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System,*” and to *“… assure the full and proper utilization of the results of scientific studies for park management decisions*.” Section 5934 of the Act requires the Secretary of the Interior to develop a program of “*inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources*.”

Congress reinforced its commitment to protecting our environment and natural resources in the FY 2000 Appropriations bill by stating that, *“The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data.”* With support from congress and the increase funding in FY2000, the NPS I&M Program began the rapid development of biological inventories and monitoring programs in each of the 32 networks. Additionally, in 2001, NPS Management Policies updated previous policy and specifically directed the NPS to inventory and monitor natural systems, *“Natural systems in the National Park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions.”* For additional statutes that provide legal direction for expending funds to determine the condition of natural resources in parks and specifically guide the natural resource management in Network parks, see NPS 2005a.

Finally, the Government Performance Results Act of 1993 (GPRA) directs a performance management system for all federal agencies and mandates annual strategic planning and annual reporting of results achieved. It requires accountability to Congress and the American people. Agencies are required to prepare an Annual Performance Plan that sets mission-based program goals and defines the level of projected performance, to meet the goals, establishes performance indicators to measure outputs if a straightforward goal cannot be developed, establishes a basis for comparing actual results with projected performance and describes a means of verifying and validating data. Importantly, goals must be expressed in objective, quantifiable and measurable form. An Annual Performance Report is required to demonstrate and evaluate performance achieved compared with projected performance in the Plan and to review success or failure in achieving annual goals. Annual Reports must explain why a goal was not met, plans to achieve the goal in the future or to recommend alterations to impractical or infeasible goals. The performance management approach is to establish goals - allocate resources to accomplish those goals - take action/complete the work- measure results - evaluate and report performance - use evaluation to adjust goals and reallocate resources - and continue the loop. This process sharpens our focus on accomplishing our mission in the most effective and efficient ways, and holds managers and employees accountable on a clear and measurable basis.

The history of performance management implementation since 1993 shows increasing accountability for performance planning and reporting by the National Park Service and increasing scrutiny and direction by the Department of Interior, Office of Management and Budget and Congress. In 1997, the National Park Service developed the first Strategic Plan to comply with GPRA. In 1998, in an apparently unique move within the federal government to have the requirements of GPRA law applied down to the individual installation level, the Thomas Bill (National Parks Omnibus Management Act of 1998) directed each unit of the National Park Service to prepare and publicize a 5-year Strategic Plan and Annual Performance Plan reflecting NPS policies and outcomes from the Servicewide Plan. In 2000, the second NPS Strategic Plan included mention of "vital signs" in the Executive Summary stating "vital signs collectively show ecosystem health" and " Identifying vital signs of ecosystems and well being of other special concern resources allows tracking the status and trends of NPS natural resources" and further states that "NPS can define "healthy" conditions, identify treatments propose mitigation".

Also in 2000, a new goal (IB3) was added so that parks may report on the identification of vital signs in the network, as was presented in the Phase 2 Monitoring Plan. The first Department of Interior Strategic Plan was prepared in 2004 and included goals to improve health of watersheds, landscapes and marine resources, sustain biological communities and protect cultural and heritage resources. All agencies in DOI are required to tier off DOI goals.

In 2005, the third NPS Strategic Plan was expanded based on the Department's identified goals. The NPS added goal IB3b "vital signs implemented" to allow parks to report on completion of a draft Phase 3 Vital Signs Monitoring Plan and many other goals to address the Departmental Plan. Implicit in performance planning and reporting is a measure of resource condition status and trends as compared to a well described desired condition of natural resources in network parks.

Mission Goals:
Natural and cultural resources and associated values are protected, restored and maintained in good condition and managed within their broader ecosystem and cultural context.

The National Park Service contributes to knowledge about natural and cultural resources and associated values; management decisions about resources and visitors are based on adequate scholarly and scientific information.

NCBN Park Legislation and Guidance

Within the Northeast Coastal and Barrier Network, four parks, Gateway National Recreation Area, Assateague Island, Fire Island and Cape Cod National Seashores, note significant natural resources in their enabling legislation. The remaining four parks, Sagamore Hill NHS, Thomas Stone NHS, George Washington Birthplace NM and Colonial NHP are either National Historic Parks, Sites or Monuments, and thus have a primary mandate to maintain historical features, cultural landscapes or practices. Although these four parks are mandated specifically to maintain their cultural landscapes these cultural landscapes are made up of important ecological features. A cultural landscape is defined by the NPS as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values."

Nearly all cultural landscapes are dependent on park natural resources. It is these interconnected, dynamic systems of land, air and water, vegetation and wildlife which have dynamic qualities that differentiate cultural landscapes from other cultural resources, such as historic structures. Thus, their documentation, treatment, and ongoing management require a comprehensive, multi-disciplinary approach, including ecological monitoring. In order to maintain the integrity of these cultural landscapes in parks, the integrity of the existing natural resources must be maintained. For example, the salt marsh at Sagamore Hill National Historic Site, and the wooded areas and streams that exist at Thomas Stone National Historic Site are all part of the cultural landscapes of these parks, but also represent significant ecological resources. In cases like these, often times cultural and natural properties are indistinguishable. The cultural landscapes of these parks include natural and cultural resources that maintain a link with a community's past and are vital to maintaining its integrity and sense of place. Although natural resources are not mentioned in their enabling legislation they were identified as having "significant natural resources" by park managers and included in the I&M Program. For each park's enabling legislation related to natural resources as well as other federal legal mandates, see NCBN 2004b.

Assateague Island NS, Cape Cod NS, Fire Island NS and Gateway NRA have specific protection responsibilities under Executive Order 13158-Marine Protected Areas (MPA). This order defines an *MPA* as "any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (Federal Register 2000). MPAs are management tools to help protect, maintain, and restore natural and cultural resources in coastal and marine waters. They have been used effectively, both nationally and internationally, to conserve biodiversity, manage natural resources, protect endangered species, reduce user conflicts, provide educational and research opportunities, and enhance commercial and recreational activities (Salm *et al*. 2000).

Finally, five parks in the Network have federally listed species, including both plants and animals. These include beach nesting populations of the federally threatened piping plover in three parks; threatened bald eagles in three parks; and the threatened sea beach amaranth in three parks. Cape Cod NS has 17 federally listed species; the most of any Network park.

Program Approach, Strategy and Goals

Biological inventories, vital signs monitoring, and research can provide information needed for effective, science-based decision-making, and with proper resource management will provide for resource protection in parks. Figure 1.2 depicts the relationships between biological inventories, monitoring, research and resource management. Biological inventories are initiated to provide baseline information about park resources such as simple presence or abundance of a species. Resource monitoring is initiated to detect resource change if it occurs. Monitoring is then complimented by research initiatives that are targeted towards determining the cause of change and the potential relationship between the stressor and the ecosystem response that has been determined by monitoring (Busch and Trexler 2003). The NPS Vital Signs Monitoring Program has been developed to directly provide inventory and monitoring information to parks. Although research plays and integral role in this science-based resource management cycle, the I&M Program will not be conducting research in the parks, but rather assisting parks and regions in identifying their research needs, based on inventory and monitoring results.

The I&M networks were established to help facilitate collaboration, information sharing, and economies of scale in natural resource inventory and monitoring. Networks were designed to provide parks with a minimum infrastructure for intiating natural resource monitoring that can be built upon in the future.

Beginning in 1992, 11 prototype monitoring programs were selectively placed in parks representing unique biomes. These programs were established as experiments in how to design scientifically credible and cost-effective ecological monitoring programs. Prototypes are well-funded and staffed, and benefit from United States Geological Survey (USGS) involvement and funding for program design and protocol development. Considered as "centers of excellence", they are able to do more extensive and in-depth monitoring than the networks, and continue research and development work to benefit the park.

In 2000, as part of the Natural Resource Challenge, and to fulfill the need to establish monitoring in all parks with significant natural resources, 32 networks were created to join the prototypes in design and implementation of institutional monitoring.

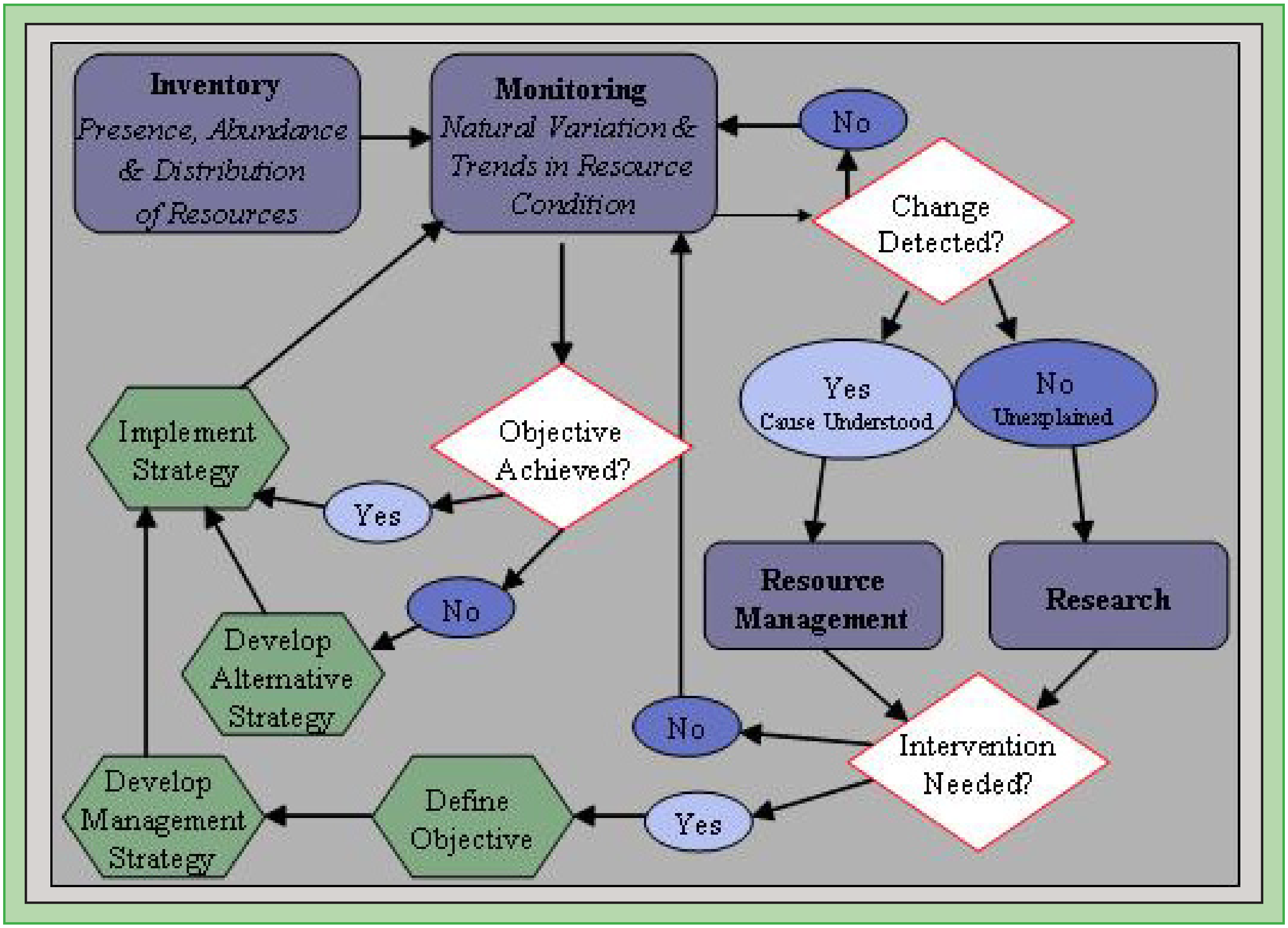

Figure 1.2. Relationships between inventories, monitoring, research and natural resource management activities in National parks (modified from Jenkins *et al*. 2002 and Elzinga *et al.* 2001)).

Cape Cod National Seashore, established as a prototype program site in 1996, serves as the prototype program for the Atlantic and Gulf Coast biogeographic region. The Cape Cod NS monitoring program is based on striving to understand the processes and component interactions governing the coastal ecosystem, and focuses on addressing management issues that confront coastal parks. Development of this program has been a collaborative effort between the USGS and the NPS. (The USGS provided funding for development of a conceptual framework for the Cape Cod NS program and for protocol development; Cape Cod NS began receiving funding implementation of the long-term monitoring program in 1997.) In 1999, Cape Cod NS was charged with developing and refining long-term monitoring protocols that could be used by other Atlantic and Gulf Coast parks.

The vision for the vital signs monitoring program is to provide network parks with consistent annual funding and a core scientific staff to support a long-term program. Each network is expected to leverage these core resources, including prototype programs, with existing personnel, funding from other sources, and partnerships with other agencies and organizations, to build a single, integrated monitoring program that best addresses the needs of the network parks. To guide the monitoring program, all 32 networks address the following five Goals of Vital Signs Monitoring as they plan, design, and implement integrated natural resource monitoring:

1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
4. Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
5. Provide a means of measuring progress towards performance goals.

NCBN Vital Signs Monitoring Program

Identifying Critical Scientific and Management Issues for NCBN Parks

Before funding became available and Networks were established in 2000, the Northeast Region of the National Park Service began to develop a strategy for the long-term protection of natural resources and ecosystems in the region's parks. During the 1990s, both USGS and NPS workshops and symposia were held to discuss the need for ecological monitoring in these parks. Although these workshops included parks outside the more recently established Northeast Coastal and Barrier Network, a number of the Network parks participated.

One of the first planning workshops was held in September 1997–a two-day workshop titled *Developing a Conceptual Design for a Multi-park, Long-term Monitoring Program in the Northeast Field Area, National Park S*ervice. Ten parks participated, including four NCBN parks (ASIS, FIIS, GATE and CACO). The purpose of this workshop was to develop a Northeast Region-wide ecological monitoring strategy.

Prior to the workshop, each participating park developed a list of natural resource related management issues for discussion. The following issues were common to all four participating NCBN parks*: adjacent land development; accelerated estuarine nutrient enrichment; increasing visitor use and recreational impacts; shoreline change; rare species-protection; water quality; and exotic species impacts*.

In the fall 1999, as part of the USGS Patuxent Annual Science Meeting, a symposium was organized called *Coastal Issues and Information Needs (PWRC 1999)*. Internationally recognized leaders in coastal ecology joined forces with DOI coastal land and resource managers to identify key scientific issues, information gaps, and long-term data needs relevant to coastal resource management. As in the 1997 workshop, the management issues identified during this meeting were similar across the coastal parks and included *adjacent land development, estuarine water quality and nutrient enrichment, increasing visitor and recreational use and impacts, shoreline erosion, and exotic species*.

In February 2000, another workshop was held in association with Patuxent, titled *Developing a Scientific Basis for Integrated Long-Term Monitoring of Atlantic Coastal Parks and Refuges*. The workshop objectives included identifying indicators for long-term monitoring that provide quantitative information on coastal ecosystem functions, and identifying threshold values for coastal ecosystem indicators that denote sustainable vs. degraded systems.

Many of the above workshops were held to assure that design of the prototype monitoring program at Cape Cod NS was relevant to Atlantic Coastal Parks. The Cape Cod program was to represent this biogeographic region. Although funding was not available to the Region prior to the NPS Natural Resource Challenge in 2000, limiting implementation of the plans and ideas discussed at these symposia and workshops, the Northeast Coastal and Barrier Network was able to use the many critical natural resource issues identified for its parks due to this valuable work and planning of scientists within the region. In particular, four important ecosystems were identified: *coastal upland; estuary and salt marsh; beach, spit and dune; and freshwater systems*. Each ecosystem already had critical issues associated and prioritized, specifically *shoreline change, estuarine nutrient enrichment or water quality, salt marsh change, and visitor impacts*.

Establishing the Network

In 1999 and 2000, I&M Program staff and cooperators were hired to begin summarizing existing data and information relating to NCBN parks, including the information resulting from the meetings and workshops previously held within the region. The NCBN Technical Steering Committee was established to advise, assist and make recommendations regarding the development and implementation of a monitoring strategy, expertise needed in Network staff, monitoring costs and sampling design, as well as other aspects of the Network program. Members of the committee were nominated by park staff, the regional I&M coordinator and regional chief scientists. Those selected included many of the scientists familiar with Northeast coastal park issues and others who had been involved with or implemented research pertaining to coastal ecosystem monitoring.

A Network Board of Directors was also established to maintain credibility for the Network. The Board includes the seven superintendents (THST and GEWA share a superintendent) from the NCBN parks, one chief scientist from the region, the Regional I&M Coordinator, and the Network I&M Coordinator. The Board meets at least once each year to review monitoring program progress, and approve work plans for spending Network funds. Members work closely with the Network Data Manager and the Technical Steering Committee and are consulted before the hiring of Network personnel. The Board also assists in developing strategies and procedures for leveraging Network funds and personnel to best accomplish inventory, monitoring, and other natural resource needs of Network parks. Board members help the Network acquire additional financial support, and facilitate a cooperative interaction with other governmental agencies, organizations, and individuals.

Identifying Issues and Initiating the Vital Signs Selection Process

In April 2000, the Northeast Coastal and Barrier Network held a Vital Signs Scoping Workshop at Gateway NRA (NCBN 2000a). This workshop included all the parks in the Network, providing the first opportunity for George Washington Birthplace NM, Thomas Stone NHS, Colonial NHP and Sagamore Hill NHS, the four smaller Network parks, to participate in identifying their significant resource issues. Workshop participants included regional coastal scientists from universities and other agencies, staff from the National Inventory and Monitoring program, and Cape Cod NS prototype program. In preparation for this workshop, the Network Steering Committee identified four ecosystems, based upon the Cape Cod NS Conceptual Framework (Roman and Barrett 1999) that could be used as a basis for discussing specific monitoring issues and help to structure the workshop and the Network's monitoring program. These were: *Estuaries and salt marsh; Freshwater wetlands, Ponds and streams; Uplands (forests, grasslands and thickets); and Beaches, dunes, spits and shoreline systems.*

Based upon prior input from the parks, other regional workshops, and park planning documents, the steering committee then selected high priority management issues relevant to all Network parks: *Shoreline Change; Water Quality; Species and Habitats of Concern; Resource Extraction; and Recreation and Visitor Use.*

Workshop participants were asked to discuss the four key ecosystems and associated management issues identified by the Network Steering Committee, and develop a preliminary list of all vital signs that should be considered for the Network vital signs monitoring program. The 41 people who attended were divided into five workgroups based on the five high priority management issues mentioned above. Each workgroup was successful in developing preliminary monitoring questions and identifying vital signs. The final workshop report includes the workgroup results (NCBN 2000a).

Following the scoping workshop, the Network Technical Steering Committee met in September 2000 to review the scoping workshop report and discuss further development of the NCBN vital signs program (NCBN 2000b). The Committee decided that the scoping workshop was successful in developing large lists of vital signs and questions for the Network, but agreed that smaller working groups were needed to review and refine the monitoring questions and vital sign lists. The Committee recommended the formation of seven issue-based workgroups: shoreline change; estuarine nutrient enrichment; freshwater quality; contaminants; recreation and visitor use; species and habitats of concern; and data management. Each workgroup was directed by a Technical Steering Committee member and included approximately five other members. It was decided during the Technical Steering Committee meeting that the water quality workgroup would be divided into two separate groups, one for freshwater and one for estuarine waters. Workgroups were asked to: review the scoping workgroup reports; refine and prioritize the monitoring questions; prioritize vital signs; evaluate existing monitoring programs; develop scopes of work to fill data gaps; identify potential cooperators; and produce a written report.

Four workgroups were successful in submitting reports to the Network: (1) shoreline change (2) estuarine nutrient enrichment (3) freshwater quality, and (4) data management (NCBN 2001a-d). Three of these groups–estuarine nutrients, shoreline change and contaminants–wrote scopes of work to initiate additional projects. The contaminants workgroup decided that a contaminants inventory should be conducted for each of the parks before any further development of this issue within the Network framework. The recreation and visitor use group recommended that the Network wait until the completion of the Cape Cod Prototype Visitor Use protocol was complete. This could then be reviewed by the Committee and potentially be adapted to meet the needs of the network-wide program. The Technical Steering Committee and Network staff also identified qualified collaborators to address gaps in other issue areas, such as species and habitats of concern (Fabre 2003).

In order to further document similar resources and management issues among the network parks, NCBN staff reviewed park general management plans (GMP) and Resource Management Plans (RMP), compiling all natural resource related issues (see NCBN 2004c for compiled lists of issues for each Network park). All ecosystems previously identified by the Network staff and Committee members were also identified as key ecosystem types within park management plans.

Network Vital Signs and Monitoring Questions

Table 1.2 includes all monitoring questions and lists of vital signs for the Northeast Coastal and Barrier Network parks compiled from the workshop reports, workgroup reports and park planning documents. The compilation of this list was used to assist the Network in prioritizing its vital signs.

NCBN Vital Signs Monitoring Scoping Projects

Although the scoping workshop participants and the working groups discussed and created these initial lists of monitoring questions and candidate vital signs for the network, NCBN staff and Technical Steering Committee members recommended hiring subject matter experts to improve and revise the questions, develop monitoring goals and objectives and prioritize vital signs. As suggested by the Network Technical Steering Committee, with final input from the Board of Directors, estuarine nutrient enrichment, visitor impacts, and coastal geomorphology were three significant subject areas that needed further input for the Network. In 2001-2002 scopes of work were created, and subject matter experts identified and funded to complete this work. The scope of

Table 1.2. Northeast Coastal and Barrier Network monitoring questions and candidate vital signs identified at April 2000 scoping session and by associated workgroups.

MONITORING QUESTION	CANDIDATE VITAL SIGNS/MEASURES
Water Quality	
Is water quality changing outside the bounds of natural variability? Are nutrient loads to park estuaries increasing? Are estuarine resources changing in response to nutrient inputs?	Autotrophic production, Nutrient load, Contaminant concentration change, Light attenuation (water clarity) change, Physical processes influencing bioavailability of contaminants, Surface and groundwater level, Water chemistry, Acid Neutralizing Capacity, Chlorophyll a, Attenuation of Photosynthetically Available Radiation (PAR), Sediment Organic Carbon, Dissolved Oxygen, Benthic Community Structure, Winter Dissolved Nutrient Concentrations, Bacteriological Monitoring, Macroalgae and SAV Parameters
Does changing water quality impact natural and cultural resources and visitor use?	Ecosystem metabolism, Watershed characteristics, Acute or chronic responses in aquatic flora and fauna communities, Community composition, distribution, and production, Responses by terrestrial vegetation and cultural resources
What are the causes of changes in water quality?	Nutrient Sources, Contaminant input
Recreation and Visitor Use	
How are the type, amount, and distribution of visitor uses changing over time?	Type of recreation use, Amount of recreation use, Distribution of recreation use
What are the effects of visitor use on vegetation?	Vegetation loss, Vegetation compositional change
What are the effects of visitor use on physical resources?	Unintended trail proliferation, Unintended recreation site proliferation, Substrate erosion
What are the effects of visitor use on wildlife?	Disturbance time, Road kills, Attraction behavior
What are the effects of visitor use on water resources?	Water turbidity, Biological contamination
Species and Habitats of Concern	
What are the changing trends of exotic and invasive species?	Distribution of invasive species, Abundance of invasive exotic species, Abundance of epiphytic algae in eelgrass beds
What factors are contributing to exotic and invasive species expansion?	Adjacent land use rate of change, Human use patterns/change, Soil disturbance
What are the effects of exotic/invasive species on Park resources?	Trends in exotics distribution and abundance, Featured species (e.g., deer, ponies), Other native species, Reproduction of other species
What are the changing trends of rare species (frequency, abundance, and distribution)?	Population status, Abundance and distribution of rare species, Community status
What are the changing trends in featured species?	Vegetation, Native freshwater fish, Amphibians, Migratory birds, Small mammals, Changes in Park resource composition

Table 1.2. Northeast Coastal and Barrier Network monitoring questions and candidate vital signs identified at April 2000 scoping session and by associated workgroups (continued).

MONITORING QUESTION	CANDIDATE VITAL SIGNS/MEASURES
What are the changes in spatial distribution and abundance of major vegetation communities?	Abundance and distribution of community types
What is the rate of change of adjacent land use?	Adjacent land use rate of change
Resource Extraction	
What are the effects of groundwater extraction on water tables (very significant), uplands, estuaries, wetlands and surface water availability?	Groundwater level/salinity
How does coastal sand mining effect hydrography (residence time, wave climate, loss of shoals, sediment budget)?	Shoreline changes, Marine hydrography
What is the frequency and intensity of sand dredging?	Bathymetry, Shoreline change through GIS
What are the effects of commercial and recreational shellfish harvesting on park aquatic habitats?	Habitat response to shellfishing, Habitat disturbance to bottom habitat and associated communities

work included: (1) data mining to identify existing monitoring programs in and around Network parks related to that issue; (2) reviewing and refining the existing monitoring questions to ensure they are realistic, specific, and measurable; (3) developing specific monitoring goals and objectives; (4) creating a list of prioritized vital signs that meet the objectives and questions (see Chapter 3); (5) and determining appropriate measures. These projects were initiated through cooperative agreements with substantial involvement from Network staff.

Although the Network's vital signs program was originally based upon four focal ecological systems, from this point forward the Network Technical Steering Committee recommended that the Network consider treating estuarine and salt marsh as separate systems, as depicted in the network conceptual models (see Chapter 2). With this change in the structure of the program, a project was initiated to determine the feasibility of adapting draft, Cape Cod NS prototype salt marsh monitoring protocols developed by USGS (vegetation and nekton monitoring) (Roman *et al.* 2001) (Raposa 2001), to the Network program.

Finally, the Technical Steering Committee recommended that landscape change monitoring be considered by the Network during a meeting in 2003 (NCBN 2003a). Up to this point the subject areas identified had been concentrated on beaches, estuaries, and salt marshes with little attention given to upland areas of the parks; landscape change was added to fill that gap.

The following summaries briefly describe the issues relating to each subject area. A general goal or set of goals based upon the workshop and workgroup generated monitoring questions is listed for each. Detailed discussion of the prioritization of vital signs and specific monitoring objectives for each can be found in Chapters 3 and 5 of this plan. Further information can be found in final reports listed below each summary. Links to all documents are available in Chapter 11, Literature Cited.

Estuarine Nutrient Enrichment

NCBN Goal: Provide information to NCBN park mangers on the status and trends of park estuarine water quality for use in management decisions and contribute to understanding and describing the condition of marine and coastal areas.

Estuaries, bays, and lagoons are islands of unique, relatively pristine, aquatic habitat within the Northeast Coastal and Barrier Network parks. These parks depend on high-quality aquatic resources both inside and outside of the park to sustain the complex estuarine and near shore ecosystems. Diverse threats to these estuaries include natural disturbances (e.g. storms, sea-level rise), direct impacts from human activities (e.g. fishing, boating, dock construction), and indirect effects of watershed development on water quality (see Chapter 2). Network park managers have repeatedly identified threats to estuarine water quality as one of their highest priority management issues. Much of the watershed area of NPS coastal ecosystems lies outside protective park boundaries and is subject to intense developmental pressures. Therefore, there is great potential for human disturbance to coastal watersheds, often resulting in increased nutrient loading to park estuaries.

Estuaries can generally assimilate some degree of enrichment without major ecological ramifications, but excessive nutrient input typically leads to dense blooms of phytoplankton and fast-growing macroalgae, loss of seagrasses, and decreased oxygen availability in sediments and bottom waters. Ultimately, cascading effects include changes in the species composition and abundance of invertebrates, decline in fish and wildlife habitat value, and the collapse of fin- and shellfish stocks. Implementing a scientifically-based monitoring program that is capable of diagnosing local causes of nutrient enrichment, detecting changes in nutrient loads, and ecosystem structure and function is essential to protecting the ecological integrity of park estuaries. See *Candidate Variables for Monitoring Estuarine Nutrient Enrichment Within the NPS Coastal and Barrier Network. Report to the NPS Coastal and Barrier Network*, (Kopp *et al.* 2002).

Geomorphologic Change

NCBN Goal: To improve the understanding of and provide information to park managers on the dynamic nature of coastlines, including the spatial and temporal patterns of change in NCBN parks for use in management decisions and describing the condition of marine and coastal areas.

The issues related to land loss or land gain at the marine/estuary edge are common among NCBN parks. Throughout the scoping process, the lack of adequate data to track and respond to geomorphologic change was consistently identified as a high priority management issue for all coastal NCBN parks. Coastal geomorphologic change can be either chronic or episodic, is often defined by linear or nonlinear time trends, and displays extensive spatial variability (Allen and LaBash 1997; Allen *et al.* 1999). Change in the position of shorelines also drives allogenic replacement of natural habitats (*c.f.* Roman and Nordstrom, 1988) and shoreline retreat may destroy cultural resources, facilities and other infrastructure within the parks.

An understanding of the spatial and temporal patterns of geomorphologic change is basic to optimal management of any coastal park. Understanding the patterns of geomorphologic change can be difficult, because the interface between marine and land systems is dynamic and driven by multiple mechanisms. It is necessary to understand these patterns because changes often result in alterations to resources and dynamics of habitat and ecosystem conditions, as well as eventual loss of static cultural resources. Coastal geomorphologic change, whether erosion or accretion, can result from both natural and anthropogenic sources. NCBN park managers want to understand the spatial and temporal variation in the frequencies and magnitudes of coastal change that affect key park resources and the overall integrity of the coast. Such understanding must identify chronic vs. extreme events, natural vs. human causes, and local vs. regional patterns of effects and allow for some aspect of predictability of future problems.

Several factors influenced how this project developed. Given the importance of understanding geomorphologic change to the parks, the amount and complexity of existing data from many sources, the active scientific community and long term research interests, the lack of a peer reviewed protocol and agreement on common parameters and methods for measuring change, a project leader was hired by the Network to put the pieces together. The project leader assembled existing data and identified existing projects, conducted workshops with experts to develop monitoring objectives, questions and protocols needed to implement a geomorphologic change monitoring program for the Network. See *National Park Service, Northeast Coastal and Barrier Network, Coastal Geomorphologic Workshops Report* (Duffy 2003).

Salt Marsh

NCBN Goals: To monitor salt marsh condition in NCBN parks in order to provide managers with information to make better informed management decisions and to work more effectively with other agencies and individuals for the benefit of these park resources.

Salt marsh loss is a concern for Network parks. Despite legal protection, salt marshes have experienced a significant area loss during the last three decades along the North Atlantic coastline (Kolker et. al. 2005). Salt marsh vegetation characteristically has extensive root systems that enable them to withstand brief storm surges and buffer storm impacts on upland areas. Salt marshes act as filters. Tidal creeks meander through the marshes transporting valuable nutrients as well as pollutants from upland development. Marshes can absorb, or trap, some of these pollutants, reducing nutrient input to both estuarine and coastal ecosystems by filtering land-derived runoff (Howes *et al.* 1996). Salt marshes also act as sediment traps, preventing sediments from washing offshore and often creating more land on which to grow.

Salt marsh provide habitat for wading birds and waterfowl including high tide refuges for birds feeding on adjacent mudflats, breeding sites for waders, gulls and terns and a source of food for passerine birds particularly in autumn and winter. In winter, salt marshes are used as feeding grounds by large flocks of ducks and geese. Areas with high structural and plant diversity, particularly where freshwater seepages provide a transition from fresh to brackish conditions, are particularly important for invertebrates. They are nursery grounds for important commercial and recreational fishes as well as species that are integral to the estuarine trophic food web (McHugh 1966, Able et al. 1988, Heck et al. 1989, Ayvazian *et al*. 1992).

Salt marsh communities often serve as biological indicators of the overall ecological health of parks because they often integrate problems and processes associated with both estuary and upland ecosystems. As part of the estuarine system, salt marshes are considered some of the most pristine aquatic habitats within the Northeast Coastal and Barrier Network parks. Unique to coastal parks, monitoring of salt marsh is important in any coastal ecosystem monitoring program. Diverse threats to salt marshes include, sea-level rise, ditching, watershed development, exotics, and many other natural and human induced changes. Salt marshes act as buffers from coastal erosion and the transition between the dynamic coastline and park upland. These communities are also very sensitive to disturbance and perturbations (sea-level rise, storms, geomorphologic processes, nutrient loading, watershed development, and human activities such as tidal restrictions and ditching).

The Cape Cod NS prototype monitoring program has developed and implemented a salt marsh monitoring program, that includes two protocols: salt marsh vegetation (Roman *et al.* 2001); and nekton (Raposa and Roman 2001) (James-Pirri *et al.* 2002). These protocols have been implemented at Cape Cod N.S. and eleven Fish and Wildlife Refuges along the Northeast Coast. The Northeast Coastal and Barrier Network

Salt Marsh project involves accepting the monitoring objectives and adapting these two protocols for use at the network level.

Visitor Impacts

NCBN Goal: Gather information that will lead to a better understanding of NCBN park visitor use.

National Park Service units that maintain high visitation, especially those along the Eastern seaboard, present unique challenges for natural resource managers. Although little information or long-term data exists in the literature related to ecosystem tolerance to human uses in parks, this kind of information is essential to park management. When park monitoring needs and issues were being identified for NCBN parks, all parks in the Network identified the need for visitor use monitoring. Faced with the often conflicting goal of conserving the natural conditions of a park as mentioned and quoted often from National Park Service legislation "… *conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations,*" and providing recreational opportunities and unlimited visitation, managers must understand the often changing dynamics of park use as well as the ecological impacts of park use.

Growing recreation use, particularly since the 1960s, has made many scientist and land managers concerned about the impacts that recreationists can inflict on natural systems. Park managers make decisions on whether or not it is necessary to curtail certain recreation uses, often with little information to base their decisions. There is a need in all parks to better understand the ecological impacts that various types of recreation activities may have. For instance the impacts that mountain bikes might impose versus hikers, etc… The need for better understanding the "limits of acceptable change" due to park uses is important. Park managers often must formally define the tradeoff between recreation use and natural resource management goals in their parks with little research or

Fire Island National Seashore, New York.

accurate information to make those formal decisions. Simply monitoring things like visitor numbers and distribution and activities within parks would provide park managers with a better understanding of park use by visitors and others. This basic information is often lacking in most parks, but very necessary. Monitoring park use, coupled with research on the ecological impacts of those uses, should provide park staff with a much better understanding of how the two are related, and in turn provide an opportunity for better management practices. See *Phase 1 Project Report, National Park Service Coastal Visitor Impact Monitoring* and *Phase 2 Project Report, National Park Service Coastal Visitor Impact Monitoring* (Monz and Leung 2003a and b).

Landscape Change

NCBN Goal: Monitor landscape change in and around NCBN parks and provide the resulting analyzed and synthesized data to park managers.

Feral ponies grazing on Assateague Island National Seashore, Maryland/Virginia.

The primary goal of this project is to develop ways to monitor landscape change in both terrestrial and sub-tidal environments within all of the NCBN parks. Landscape change monitoring will provide an important and necessary tool for future management practices. The Network's science committee identified terrestrial and aquatic vegetation monitoring as a priority issue to be addressed by the Network program. Landscape change monitoring will help to establish a landscape context for each park, giving natural resource managers a better understanding of how park ecosystems fit into the broader landscape, and will assist them in prioritizing ecosystem management. An assessment of landscape changes over time will provide estimates of habitat changes within and around parks that can also help to identify priority ecosystems in need of further research efforts within the parks. The quantification of landscape changes over time can be used to examine relationships between landscape change and wetland plant communities (Lopez *et al*., 2002), water quality, and general ecosystem health (Paruelo *et al*., 2001). By developing and implementing a protocol to efficiently and cost effectively monitor landscape change within NCBN parks, the current knowledge of park ecosystem dynamics will be further advanced, allowing for better management practices and decision making in the future.

Following the completion of the Phase II vital signs monitoring plans by the first twelve I&M Networks in October 2003, the National I&M program compiled the list of vital signs selected by each network and compared them. Land use/ land cover change was the most commonly selected vital sign among the networks. Given the overwhelming interest in this particular vital sign, a workgroup was created by the national program to explore ways to develop protocols for landscape change monitoring. The National Program convened a meeting in January 2004, with Network Coordinators and other key scientists working on landscape change monitoring issues, to discuss the idea of creating a national landscape change monitoring protocol that could be used and adapted by the Networks.

Prior to the national landscape change monitoring meeting, the network had initiated a project with Dr. Y.Q. Wang (University of Rhode Island) to investigate whether Satellite data could be used to define habitat or land cover classes from the newly completed vegetation map for Fire Island NS and to begin producing a protocol for change detection analysis. The first part of this project involves exploration of new data and approaches that could efficiently update the vegetation map for Fire Island NS and other Network parks on a regular basis using remote sensing data. This will involve comparing and validating the agreement between satellite derived vegetation maps and the delineation result from the previous aerial photo-based project, with the hope that creating updated vegetation maps and monitoring of vegetation change can be repeated in a reasonable time frame and cost. The second part of the project includes extending the vegetation map by mapping terrestrial near-shore vegetation and seagrass beds on Fire Island using high spatial resolution Quick Bird 2 multi-spectral satellite remote sensing data.

If successful, this will allow the Network to develop a cost effective program of landscape change monitoring. Although the National I&M Program has plans to develop a protocol for landscape change, the network will continue to work with Dr. Wang to complete the protocol initiated by this project. Once a national protocol is complete the Network will revise and incorporate important aspects of the National protocol into the Network's protocol.

Integration of Water Quality Monitoring and NCBN Vital Signs Monitoring

The NPS Water Resources Division has provided funding to each network to develop and implement a water quality monitoring component as part of their vital signs programs (see NPS 2003a). The concept is to fully integrate the design and implementation of water quality monitoring with each network vital signs monitoring program. Because estuarine systems represent the largest category of water resources in the Network, they will be the focus of all network water quality monitoring within the NCBN Vital Signs Program. The NPS Water Resources Division has given networks the option to either produce a single, integrated monitoring plan that incorporates water quality monitoring within its vital signs monitoring plan, or as a separate document that describes plans for implementation of water quality monitoring. The NCBN has produced an integrated monitoring plan incorporating all network vital signs monitoring, including water quality monitoring in park estuarine systems.

In 2002, the Network initiated a network-wide wetland scoping/data mining project. This project identified 305(b) and 303(d) listed waters in each of the parks in both fresh and salt water systems, as well as provided statistics on wetland areas and wetlands potentially impacted by impaired waters. The report also describes past and current water quality monitoring programs within the eight NCBN park units. The final report was completed in 2004 (James-Pirri 2004), it provides an extensive review of water quality conditions and actions within each NCBN park.

Integration of Air Quality Monitoring and NCBN Vital Signs Monitoring

Although none of the NCBN parks are in designated Class 1 air quality areas, and air quality was not selected among the highest priority vital signs for the NCBN, it is an important component of the health of all National Parks. Air quality monitoring and reporting will be conducted for NCBN parks through a coordinated national effort by the NPS Air Resources Division (ARD). Nitrogen deposition and atmospheric ozone are air pollutants of significant concern for NCBN parks. Information regarding the status of ozone, visibility, and wet deposition of nitrogen and sulfur in all Inventory and Monitoring parks, including the NCBN parks, will be provided by ARD annually to the Networks for inclusion in Network reports. At multi-year intervals, trend analyses will also be performed and reported for ozone, visibility and nitrogen and sulfur deposition. In addition, other air quality parameters being monitored in or near many National Parks are dry deposition of nitrogen and sulfur, and mercury deposition. As appropriate, the NCBN will report on these parameters.

The status and trends of air quality parameters for NCBN parks will be determined by a combination of in-park monitoring stations and interpolation of regional data. Monitoring of wet and dry deposition of sulfur and nitrogen through the National Atmospheric Deposition Program (NADP) is ongoing at Cape Cod NS and Assateague Island NS. Visibility monitoring is ongoing at Cape Cod NS through the IMPROVE program. Also, ozone is monitored at Cape Cod NS and at a summer-only station at Assateague Island NS. For the other NCBN parks, data from regional monitoring stations will be interpolated to create averaged values for each park for these parameters. A baseline inventory of air quality parameters for NCBN parks is available on the NPS Air Resources Division website at: http://www2.nature.nps.gov/air/Permits/ARIS/networks/ncbn.htm. In addition, the ARD has completed an inventory of air pollution sensitive resources, or 'air quality related values,' for all NCBN parks. The air quality related values inventory is available at the same website.

Ozone is the pollutant for which monitoring has been most widespread in locations along the Northeast coast. The general protocol used for ozone monitoring is available in the Inventory and Monitoring Program's protocol database at http://science.nature.nps.gov/im/monitor/protocoldb.cfm. Recent data show that all NCBN parks with on-site or nearby monitoring are in ozone non-attainment areas, meaning that the ozone levels in those areas exceed EPA's human health-based 8-hr National Ambient Air Quality Standard. These data did not assess Assateague Island NS or George Washington Birthplace NM, though it is likely that they would also have non-attainment status. In order to address the lack of data for Assateague Island NS, the ARD recently deployed a portable ozone monitor at the park for summer-only use. The portable monitor provides a relatively inexpensive means of establishing baseline concentrations, documenting spatial and temporal differences in ozone, and ground-truthing interpolated ozone values.

The ARD completed the Ozone Injury Risk Assessment for NCBN in October 2004. According to this assessment, all NCBN parks were rated at high risk for ozone injury to vegetation except for Assateague Island NS, which was rated at moderate risk. The risk assessment, which is available at http://www2.nature.nps.gov/air/Permits/ARIS/networks/ncbn.htm , considered presence of ozone-sensitive species, ozone exposures, and environmental conditions (i.e., soil moisture) in the analysis. Lists of ozone sensitive plant species for each park are included in the assessment.

Partnership Opportunities and Existing Monitoring Programs

As part of the Network's scoping effort, staff and cooperators reviewed existing monitoring programs that occur within or near Network parks. These reviews provide multiple benefits to the Network I&M Program—a broad survey of valuable natural resource information for Network parks, access to data sets and protocols that can be incorporated into the vital signs monitoring program, and information on potential collaborators for inventory and monitoring projects.

There is wide variation in the monitoring programs associated with Network parks and resources. These range from short term local projects with only informal protocols, to long term regional or national programs with tested and published protocols. Some of these projects will become part of the overall vital signs monitoring program. Numerous and widespread monitoring programs (historic or ongoing) have been conducted for land cover and vegetation types, freshwater and estuarine water quality, submerged aquatic vegetation, mussels and oysters, fisheries, land birds, shorebirds, and waterfowl, and to a lesser degree mammals, reptiles, and amphibians. Also, species-specific monitoring programs have occurred for piping plover, tern species, rare coastal plant species, white-tailed and sika deer, and feral horses on Assateague.

The network is currently developing a database to house information on existing monitoring programs going on in and around NCBN parks that will easily be searchable and kept up-to-date for use by the parks. NCBN will report on these programs as needed. This database will be available on the Network's website once it is completed.

Conceptual Models

As part of the vital signs and critical issue identification phase, each I&M Network developed conceptual models to assist with prioritizing vital signs. Chapter 2 of this plan includes six models developed by the NCBN. These models are based upon the five ecosystems identified as part of the Cape Cod Prototype Monitoring Program and the NCBN program: estuarine, salt marsh, beach-spit-dune, upland and freshwater systems. The major external activities or processes that influence these natural systems, either natural processes or human activities, and the associated problems or products of human activities or natural events that alter the quality or integrity of these ecosystems are identified within each model, as well as the ecosystem response.

Chapter 2 Conceptual Models

Introduction

This chapter presents six conceptual models developed by the Northeast Coastal and Barrier Network in collaboration with both federal (USGS) and academic cooperators. These models were developed to guide the design of the Network's monitoring program. Development of these models is a necessary step in the design of all Network monitoring programs. Ecological monitoring programs in general often fail to formulate meaningful monitoring strategies. Conceptual models provide a framework for clarifying these strategies, enabling us to progress from general to more specific monitoring questions (Gross 2003). Monitoring efforts must be based on some understanding of how the ecosystem in question works. Ecosystem modeling promotes communication among scientists, managers and often the public and provides a means for evaluation and discussion of ecosystem components.

Conceptual models are tools that can help us understand and discuss ecological complexity. They allow us to structure, select, and develop monitoring protocols by:

- organizing large amounts of information
- simplifying and clarifying the relationships among ecosystem components and processes
- showing how ecosystem components interact with each other and influence other ecosystems

Conceptual models are especially effective in Network-wide, multi-park programs where the interactions among ecosystems within a group of parks are complex and difficult to interpret. A conceptual model identifies and links these interactions and describes primary relationships:

- external activities or processes that influence the ecosystem

Winter salt marsh at Assateague Island National Seashore

- problems or products of human activities or natural events that alter the quality or integrity of the ecosystem
- measurable changes in ecosystem structure, function, or processes

Types of Conceptual Models

Monitoring programs frequently use one of two model types—*control models* or *stressor models*—and sometimes both in combination. Control models simulate feedbacks and elementary connections between system components. Stressor models usually do not simulate feedback loops and include a subset of system components (Gross 2003). Stressor models show the major external activities or processes that affect an ecosystem and its response to these changes, including associated problems. Since we can define the links within conceptual models in many ways, no one conceptual model is necessarily more correct or useful than another. Instead, specific circumstances will determine the appropriate model to use.

Northeast Coastal and Barrier Network's Ecosystem Models

For the Network, conceptual models have been used to highlight issues relevant to coastal systems. These models are not intended to represent a comprehensive account of the entire coastal system, but instead, to provide a visual framework of the issues related to the Network's ecosystems. While these simplified conceptual models may understate the comprehensive nature of coastal ecosystems; they serve to demonstrate the complexity of these system relations, many of which are unknown (Roman and Barrett 1999).

The NCBN vital signs program has developed stressor models to represent the five main ecosystem types within its parks, estuaries, salt marshes, freshwater, beaches/dunes, and uplands. These models show the complex relationships among:

- *Agents of Change*, or the major external activities or processes that influence the natural system, which can be natural processes or human activities
- *Stressors* to each system, or the associated problems or products of human activities or natural events that alter the quality or integrity of the ecosystem
- *Ecosystem Responses*, or the measurable changes in ecosystem structure, function, or process

Initially, the NCBN developed a single hierarchical model, or general ecosystem model, depicting the overall *agents of change*, *stressors,* and *ecosystem responses* relative to all eight of the NCBN parks. Using this model as a basis, the Network developed five additional hierarchical ecosystem-specific models. These models demonstrate some of the human and natural activities and processes that are often the sources of stress on these systems. All six models continue to serve as a foundation for selecting vital signs for the NCBN monitoring program. They have also provided guidance and structure for the development of monitoring protocols.

The NCBN General Ecosystem Model

The Network's general model (see Figure 2.1) focuses on five broad categories of *agents of change*:

- <u>Natural Disturbance,</u> which includes geomorphic and biotic processes. For example, sea level rise, predation, grazing, fires, and storms (hurricanes, floods, droughts)
- <u>Land Use,</u> which includes any change in activity in land use patterns that influence natural systems. For example, watershed development, atmospheric inputs (pollution), population trends, and agriculture
- <u>Resource Consumption,</u> such as groundwater extraction, fin and shell fishing, hunting, and sand mining
- <u>Visitor and Recreation Use,</u> which includes activities such as trail formation, vegetation trampling, soil compaction, and wildlife disturbance
- <u>Disasters,</u> such as oil and other chemical spills, which can also play a role in shaping natural systems

In addition, watershed condition significantly affects coastal environmental quality in parks. Coastal watersheds or land areas that drain into the coastal zone are nature's dynamic hydrologic systems, creating and sustaining aquatic ecosystems. Unfortunately, impaired watersheds also convey pollutants and sediments into park waters, undermining critical habitat of the coastal parks. Many water quality issues and ecosystem problems derive from watershed conditions beyond any specific water source. To respond effectively, NPS needs to better understand watershed use, conditions, trends, and problems affecting all coastal watersheds where parks are located. Thus, NPS is developing a coordinated strategy for assessing coastal park watersheds and addressing these threats.

In the general model, six *stressors* result from these five categories of *agents of change*: altered hydrologic properties, altered landscape, invasive species, over harvesting, altered sediment inputs, and altered chemical inputs. The general model groups *ecosystem responses* into three major categories:

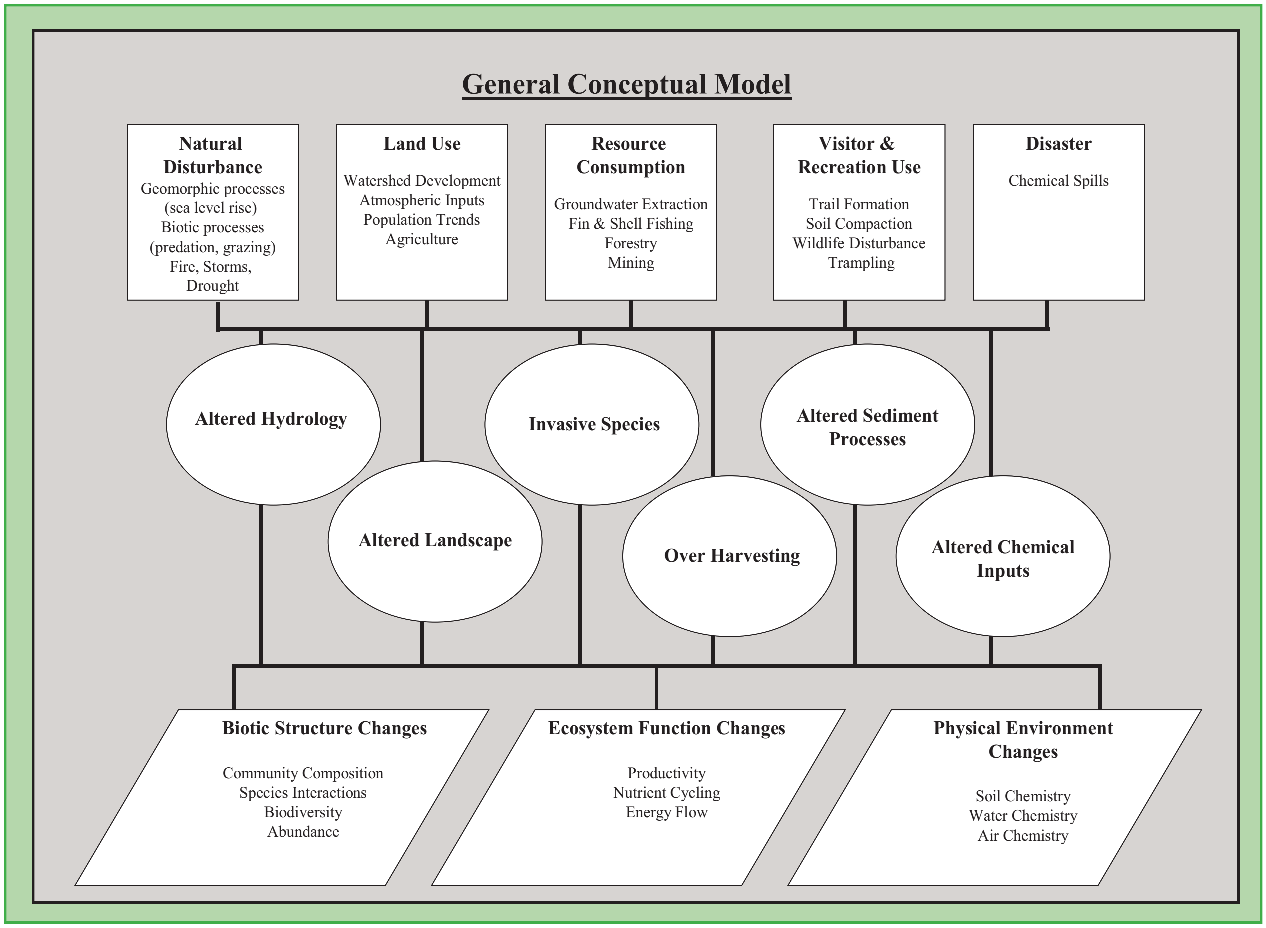

Figure 2.1. Northeast Coastal and Barrier Network general conceptual ecosystem model. (Note: Squares=Agents of Change, Ovals=Stressors, Parallelogram=Ecosystem Responses)

- Biotic Structure Changes that can modify community composition, species interactions, biodiversity, and abundance
- Ecosystem Function Changes or alterations in productivity, nutrient cycling, and energy flow
- Physical Environment Changes that can encompass changes in soil, water, and air chemistry

Depending on the ecosystem type (e.g., estuaries, salt marshes, etc.), the *agents of change* can form a wide array of links to the *stressors* listed in the model. For example, a change in land use patterns, with a corresponding increase in watershed development and urbanization within the coastal zone, can modify chemical, sediment, and hydrologic inputs within all coastal ecosystems. Woodlands become commercial or housing developments. The ecosystem responds to this urbanization; wildlife habitat is destroyed; there is increased nutrient loading from septic and sewer systems; changes in air chemistry result from automobile emissions; and community composition changes, often dramatically.

Five NCBN Ecosystem Models

The following five ecosystem models are specific to salt marshes, estuaries, freshwater, beaches/dunes, and uplands.

Salt Marsh Ecosystem Model

Salt marsh ecosystems provide habitat for many species of recreational and commercial fishes, forage species, migratory shorebirds, and water birds. They act as erosion buffers and filters of nutrient inputs by intercepting and absorbing land derived runoff (see Figure 2.2). An estimated fifty percent of the coastal wetlands in the United States have been completely lost, mostly by filling and dredging activities (Dahl 1990; Tiner 1984). Restoration and subsequent monitoring of salt marsh habitat has become only recently a management tool to rectify past environmental change. (See Roman *et al.* 2001 for more details.)

Salt marshes have a long history of alteration by extensive networks of ditches, which have been used for mosquito control and salt hay farming. Tidal exchange has been restricted by roads, causeways, bridges, and dikes (Daiber 1986; Roman *et al.* 2000). As the coastal corridor has become more urbanized, watersheds have become increasingly developed. Salt marsh acreage has declined and become fragmented. Urbanization has brought more septic and sewer systems, more air pollution, and intensified recreational use of coastal areas.

The ecosystem structure of salt marshes dramatically changes in response to ditching activities (e.g., Bourn and Cottam 1950; Niering and Warren 1980) and the restriction of tidal flow (Roman *et al.* 1984, 1995). Ditching can cause a marsh to become drier. Less salt-tolerant or flood-tolerant species may dominate (e.g., *Iva frutescens* and high marsh species). Restricting tidal flow often results in a change from *Spartina* dominated to *Phragmites australis* dominated marshes, which encourages other invasive species, leading to further changes in ecosystem structure and function. Fortunately, re-establishment of hydrologic conditions that were altered by ditching or tidal restriction often initiates a change or recovery back to typical marsh vegetation (Burdick *et al.* 1997).

Increased loading of nutrients or toxics to salt marshes, from coastal development served by on-site septic systems, alters ecosystem function and water quality.

Fall salt marsh at Cape Cod National Seashore

With nutrient enrichment of the coastal zone, expect primary production is expected to increase, leading to habitat disturbances. Sampling along a nutrient gradient in Narragansett Bay in 1973, Nixon and Oviatt found that production was substantially greater in high nutrient areas of the Bay compared to the lesser-developed and low nutrient sites.

Global climate change phenomena, such as a rise in sea level, can influence salt marsh ecosystems. Current estimates suggest that sea level along the Atlantic coast will rise 0.5m by 2100 (Intergovernmental Panel on Climate Change 1995). Changes in vegetation, sedimentation, and erosion rates, or the conversion of marsh to mudflats or open water could result (Titus 1991). Salt marshes in New England appear to be adjusting to the rise in sea level, but some locations report changes indicating that the marshes are getting wetter and tending toward submergence or drowning (Warren and Niering 1993; Roman *et al.* 1997). Inlet migration significantly influences the hydrologic characteristics and sedimentation of marsh-dominated estuaries (Aubrey and Speer 1985). Dramatic changes in structure can be an ecosystem's response to these new and often unpredictable inlet dynamics and sea level rise (Roman *et al.* 1997).

Other factors related to climate change can affect salt marsh ecosystems. For example, higher air temperatures

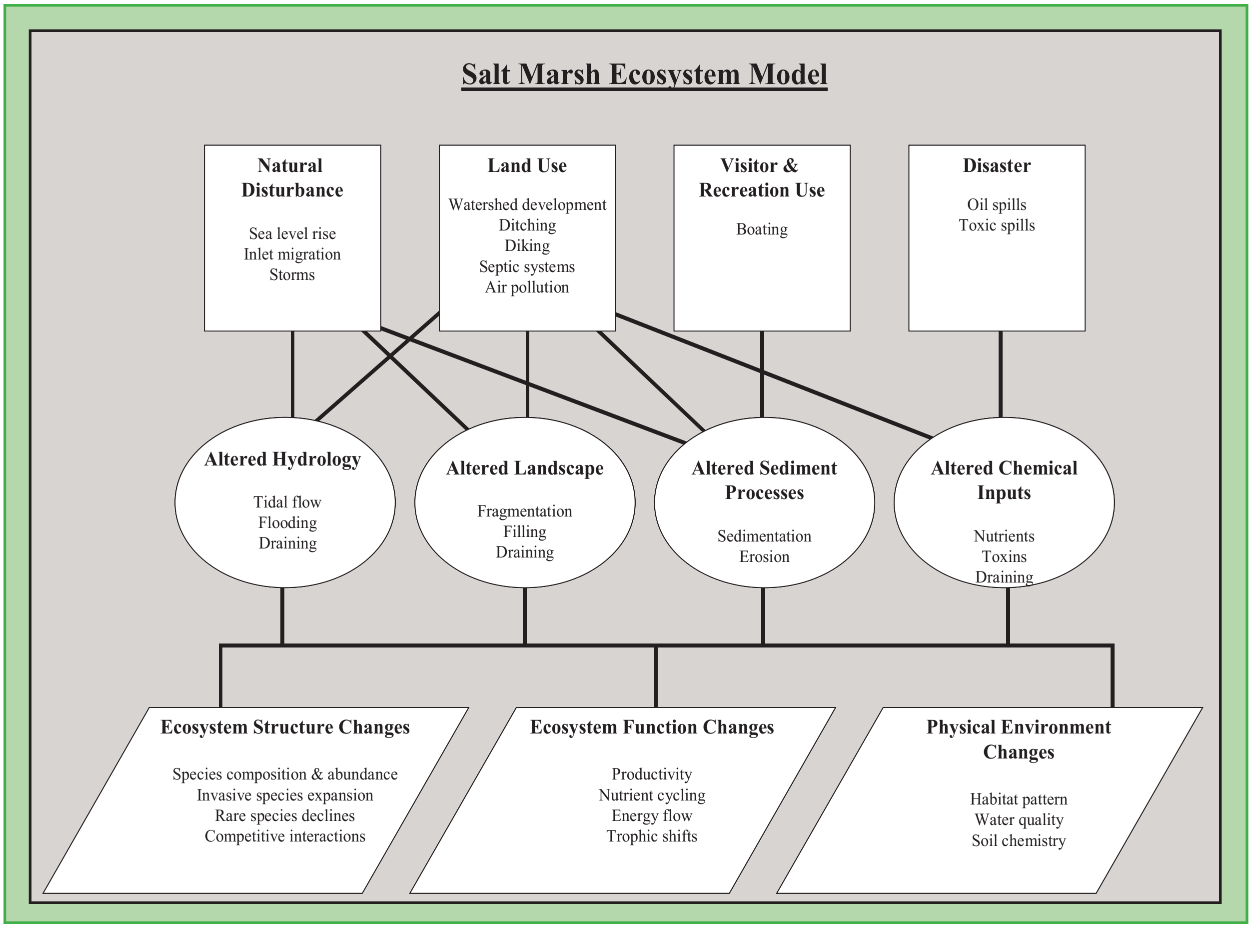

Figure 2.2. Northeast Coastal and Barrier Network salt marsh ecosystem conceptual model. (Note: Squares=Agents of Change, Ovals=Stressors, Parallelogram=Ecosystem Responses)

boost evaporation rates, leading to an increase in marsh salinities and changes in soil chemistry. This could result in the expansion of extreme salt tolerant halophytes and un-vegetated marsh pannes. Currently, salt marshes in more southern latitudes (e.g., Southeast Atlantic) with warmer climates generally have greater occurrences of halophytes adapted to extremely high soil salinity conditions (Bertness 1999).

Estuarine Ecosystem Model

Estuarine ecosystems are deep and shallow subtidal habitats and adjacent intertidal wetlands, usually semi-enclosed by land, and having open, partially obstructed, or sporadic access to the ocean. The ocean water is at least occasionally diluted by freshwater runoff (Mitsch and Gosselink 1986). Many different habitat types are found in and around estuaries, including shallow open waters, freshwater and salt marshes, sandy beaches, mud and sand flats, rocky shores, oyster reefs, mangrove forests, river deltas, tidal pools, seagrass and kelp beds, and wooded swamps.

Estuaries are critical for the survival of many species. Many marine organisms, including most commercially valuable fish species, depend on estuaries during some stages of their development. Tens of thousands of birds, mammals, fish, and other wildlife depend on estuarine habitats as places to live, feed, and reproduce. Estuaries provide ideal respites for migratory birds to rest and refuel during their journeys. And many species of fish and shellfish rely on the sheltered waters of estuaries as protected places to spawn, giving them the nickname "nurseries of the sea" (NERRS 2003).

The wetlands that fringe many estuaries are critical habitat for wildlife and perform many valuable services. As the water flows through fresh and salt marshes, much of the sediment and pollutants from the uplands are filtered out, benefiting both human and marine life. Wetland plants and soils act as a natural buffer between the land and ocean, absorbing flood waters and dissipating storm surges. This helps protect upland organisms and valuable real estate from storm and flood damage. Salt marsh grasses and other estuarine plants also help prevent erosion and stabilize the shoreline (NERRS 2003).

Our rapidly increasing human population demands more and more of our natural resources. Protecting these resources for their natural and aesthetic values has become both critical and more challenging. Channels have been dredged within estuaries; marshes and tidal flats have been filled; waters have become polluted; and shorelines have been reconstructed to accommodate our need for housing, transportation, and food. National Park Service units along the North Atlantic coast protect approximately 1,891 square kilometers between Virginia and Maine. One fourth of this land area is submerged, including many coastal bays, estuaries, and lagoons (NPS 2000).

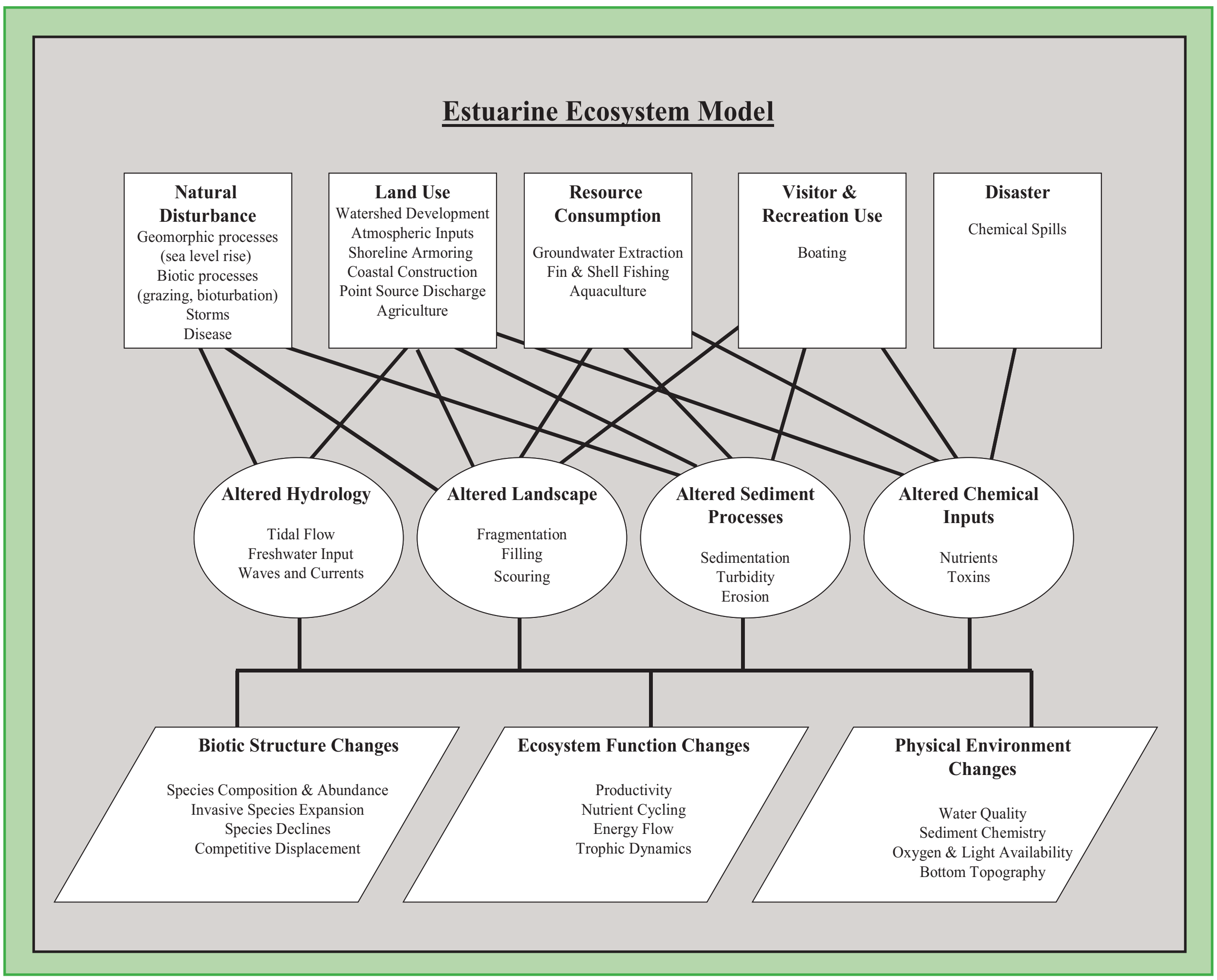

Figure 2.3. Northeast Coastal and Barrier Network estuarine ecosystem conceptual model. (Note: Squares=Agents of Change, Ovals=Stressors, Parallelogram=Ecosystem Responses)

Agents of Change

The NCBN conceptual model for estuarine ecosystems identifies five agents of change: Natural Disturbance, Land Use, Resource Consumption, and Visitor and Recreation Use. These include resource consumption, visitor recreation, storms, disease, and geomorphic and biotic processes (see Figure 2.3).

Natural Disturbance
Natural disturbances can completely alter an ecosystem. Shoreline geomorphic processes (e.g., beach and barrier migration; alongshore sediment transport) can alter depth profiles, change inlet morphometries, and bury estuarine biota. Natural coastal erosion is exacerbated by storms and hurricanes. For example, severe weather can create or block inlets to an estuary, altering hydrologic properties and the landscape. The biotic processes, within an estuarine ecosystem will likely change and affect other processes. Grazing (e.g., by Canada geese) and disturbance of bottom sediments (e.g., by foraging activities of horseshoe crabs and cownose rays) can have local impacts on seagrass cover. Disease may have widespread impacts on estuarine seagrasses. For example, in the 1930's, eelgrass (*Zostera marina* L.) populations declined throughout most of its range from an epidemic of wasting disease (infection by the marine slime mould *Labyrinthula zosterae*).

Land Use/Disasters
The Northeast (from Maine to Maryland) accounts for about one third of the coastal population of the United States (NOAA 1998). The population density of this narrow coastal fringe is more than double that of any other region of the USA, and it continues to grow. Therefore, estuaries in the northeastern USA are particularly threatened by human disturbances within the densely populated coastal zone (Roman et al. 2000). Direct disturbance arises from coastal construction, dredge and fill activities, and shoreline stabilization (*e.g.,* with bulkheads, revetments, riprap, and other types of shoreline armor). Indirect effects of residential, agricultural, and urban watershed development include increased nutrient loads to estuarine environments from atmospheric inputs, point source discharges, and diffuse non-point sources.

Aerial photo of Jamestown Island, Colonial National Historical Park, Virginia.

Resource Consumption
The loss or lack of some resources can dramatically affect estuarine ecosystems. For example, much of the watershed area of the NPS coastal ecosystems lies outside protective park boundaries and is subject to intense developmental pressures. More and more groundwater is required for residential and commercial use including agriculture. Excessive groundwater extraction can decrease freshwater input to estuarine ecosystems, thereby altering the flushing rates, retention times, and salinity regimes. We know of many acute and chronic effects of certain commercial fishing practices. For example, trawling, dredging, and raking for bay scallops and hard clams can damage eelgrass beds on the mid-Atlantic coast. Dragging for blue mussels can have severe and long lasting effects on eelgrass in New England. Fin and shellfish aquaculture operations can shade estuarine substrate and introduce large amounts of organic matter and nitrogenous waste into estuarine waters.

Visitor and Recreation Use
As populations in the Northeast continue to grow, we

can expect more visitors to our Northeast National Parks, which will alter landscapes, sediment processes, and the chemical composition of the ecosystem. For example, visitors to the NCBN parks commonly use boats and jet-skis as recreational vehicles, which alter sediment processes by increasing turbidity in shallower aquatic areas such as estuaries. Fuel spills and the discharge of contaminated bilge water into estuarine waters from pleasure boats change chemical composition. Direct damage to seagrass beds from boat propellers, anchors, and mooring chains increases local disturbance with the potential for large-scale cumulative impacts.

<u>Stressors</u>

Altered Hydrologic Processes

Water plays a vital role in maintaining a healthy estuarine ecosystem. Changes to tidal flow and variation in freshwater input can affect salinity, water temperature, and depth of water within an estuary. Natural events (e.g., storms) cause short-term increases in wave size and frequency and current speed and volume. Natural events (e.g., barrier breaches, inlet closure) and human disturbance (e.g., shoreline stabilization) can lead to long-term alterations in wave climate and current regime.

Altered Landscape

Most *agents of change* can cause small-scale disturbances in estuarine environments that, on a larger scale, result in fragmentation of specific habitat types. For example, direct physical disturbance, biotic processes, and recreational boating activities can transform continuous seagrass beds into islands of vegetation surrounded by bare substrate. Filling or scouring caused by various natural and anthropogenic disturbances can alter estuarine depth contours.

Altered Sediment Processes

Some recreational activities, such as boating, can increase the turbidity within an estuary. The dredging of channels significantly increases turbidity within an ecosystem. Increased turbidity, in turn, decreases the availability of light, reducing water quality.

Increased land development for timber, agriculture, residential and commercial purposes can lead to erosion and excessive sedimentation. Sediments are often deposited downstream along coastal shorelines. Excessive sediments not only increase turbidity, but they can also carry excessive nutrients and pesticides, causing water quality problems. Natural disturbance events (e.g., storms and hurricanes) often cause erosion.

Altered Chemical Inputs

The major land-derived sources of nutrient pollution are fertilizers and wastewater (Valiela *et al.* 1992; Nixon 1995). Nutrients from agricultural fields and domestic septic systems enter streams and groundwater through runoff and leaching, where they contribute to non-point sources of enrichment. Domestic wastewater is also delivered to estuaries as point-source sewage discharge.

High rates of urbanization and agricultural expansion can lead to increased nutrient loads in streams and groundwater (Valiela *et al.* 1992; Nixon 1995). Atmospheric deposition of nitrogen from fossil fuel combustion and fertilizer volatilization may also form a significant portion of the total nitrogen load to coastal waters (Nixon 1995), particularly in estuaries that are large relative to the size of their watersheds (NRC 2000). Acute disasters such as oil and chemical spills may introduce toxins into estuarine environments.

<u>Ecosystem Responses</u>

Ecosystem Function Changes

Understanding how all the components of an ecosystem function together is impossible. Interactions are too complex, and in some systems some of the components are unknown or poorly understood. However, we know that a healthy ecosystem depends on balancing its resources. When one or more of these resources are stressed beyond recovery, the ecosystem falters, which could eventually lead to a failure. Stressors such as altered hydrology, landscape, sediment processes and chemical inputs can all contribute to changes in native plant and animal productivity, trophic dynamics, energy flow, and nutrient cycling. Changes to ecosystem function ultimately alter biotic structure and the physical environment.

Biotic Structure Changes

The tidal, sheltered waters of estuaries support unique communities of plants and animals, specially adapted for life at the margin of the sea. The productivity and variety of estuarine habitats foster an abundance and diversity of wildlife. Shorebirds, fish, crabs and lobsters, marine mammals, clams and other shellfish, marine worms, sea birds, and reptiles are some of the animals that live in estuaries. These animals are linked to one another and to specialized plants and microscopic organisms through complex food webs and other interactions. In an altered ecosystem, native species biodiversity and abundance often decline while exotic and invasive species abundance increases and expands. Changes in biotic structure include shifts in abundance of various native species, for example, competitive displacement of seagrasses by algae following nutrient enrichment. Cascading effects of shifts in composition and abundance of primary producers may include changes in the species composition and abundance of invertebrates and declines in fish and wildlife habitat value.

Physical Environment Changes

Changes in the physical characteristics of estuarine environments will have far-reaching effects on the health of the ecosystem. Any change in water quality, whether from increased concentrations of nutrients and suspended material, decreased oxygen availability in bottom waters, decreased transmission of light to submerged rooted vegetation, increased organic content of sediments, or altered biogeochemical cycling, can be critical. Altered landscapes and sediment processes can change bottom topography, depth contours, and other hydrologic properties. These changes in the physical environment will influence and be influenced by the structure of estuarine biotic communities, and ultimately, determine ecosystem function.

Beach/Dune Ecosystem Model

Several fundamental processes drive the formation and evolution of Beach/Dune habitat, but a controlling factor in their expression is their shallow geologic framework, defined here as the “geologic properties of the near subsurface.” The regional geologic framework exercises considerable influence over the response of near shore and onshore environments to natural forces. Although not a process, this geologic framework is critical to our understanding of short and long-term changes in coastal habitats. Operating on top of this framework are numerous natural and anthropogenic factors.

The primary natural processes influencing Beach/Dune habitat are hydrographic conditions, sediment supply, and a suite of natural disturbance factors operating at local, regional, and global scales. Hydrographic conditions encompass a combination of physical and hydrologic features, such as the near shore system of bars, ridges, and shoals, and the continuous movement of water (currents, waves, and tides). Collectively, these features and forces direct and control the movement of sediment through the near shore system.

Beach/Dune habitat depends on the availability of appropriately sized sediments within near shore coastal environments. Along the mid-Atlantic coast, the availability of sediment is a limiting factor in the landform’s response to the forces of wind and waves. Also, the availability of sediment is susceptible to human disturbance and interruptions.

In the mid-Atlantic region of North America, natural disturbances consist mainly of atmospheric processes that provide both continuous and episodic energetic inputs to the system. They create wind, waves, and currents, which are the primary forces driving sediment transport in Beach/Dune habitat.

Changes in relative sea level result from a variety of global and local inputs including changes in ocean volume, tectonic seafloor shifts, and localized subsidence and rebound at the continental margins. Sea level change leads to the gradual shifting of the land/water interface (shoreline) in long-term patterns of retreat or advance. In contrast, storms provide short-term energy pulses that can rapidly reshape

Beach/Dune habitat. Whether expressed as tropical (e.g., hurricanes) or extra-tropical (e.g., nor'easters) systems, storm events move very large volumes of sediment (erosion and deposition) and can cause major habitat alterations through overwash-induced flooding and inlet formation. They may also cause substantial changes to near shore subaqueous topography and subsequently affect hydrographic processes.

Anthropogenic activities also have the potential to substantively alter the natural processes controlling Beach/Dune habitat, primarily through changes in land use within the coastal zone. Most significant are shoreline stabilization activities (e.g., groins, jetties, and bulkheads), beach "nourishment" (to artificially increase local sediment supply), and dredging activities. Each of these activities has the potential to alter existing hydrographic conditions and sediment supply, and they may influence natural patterns of erosion/deposition, overwash, inlet formation, and migration. When this occurs, core processes are altered, and naturally occurring stressors may begin to operate outside the range of natural variation. For example, a chronic sediment deficit caused by an upstream groin field or jetty system can result in dramatic changes in the volume and elevation of downdrift landforms. In turn, lower elevations facilitate overwash during storms and, consequently, may increase the potential for breaching and new inlet formation. Both are naturally occurring stressors acting on coastal barriers, which are subject to influence by human activities.

Each of the stressors identified in the conceptual model (see Figure 2.4) cause change in Beach/Dune habitat, regardless of whether they operate as natural phenomena or as a product of human activities. The

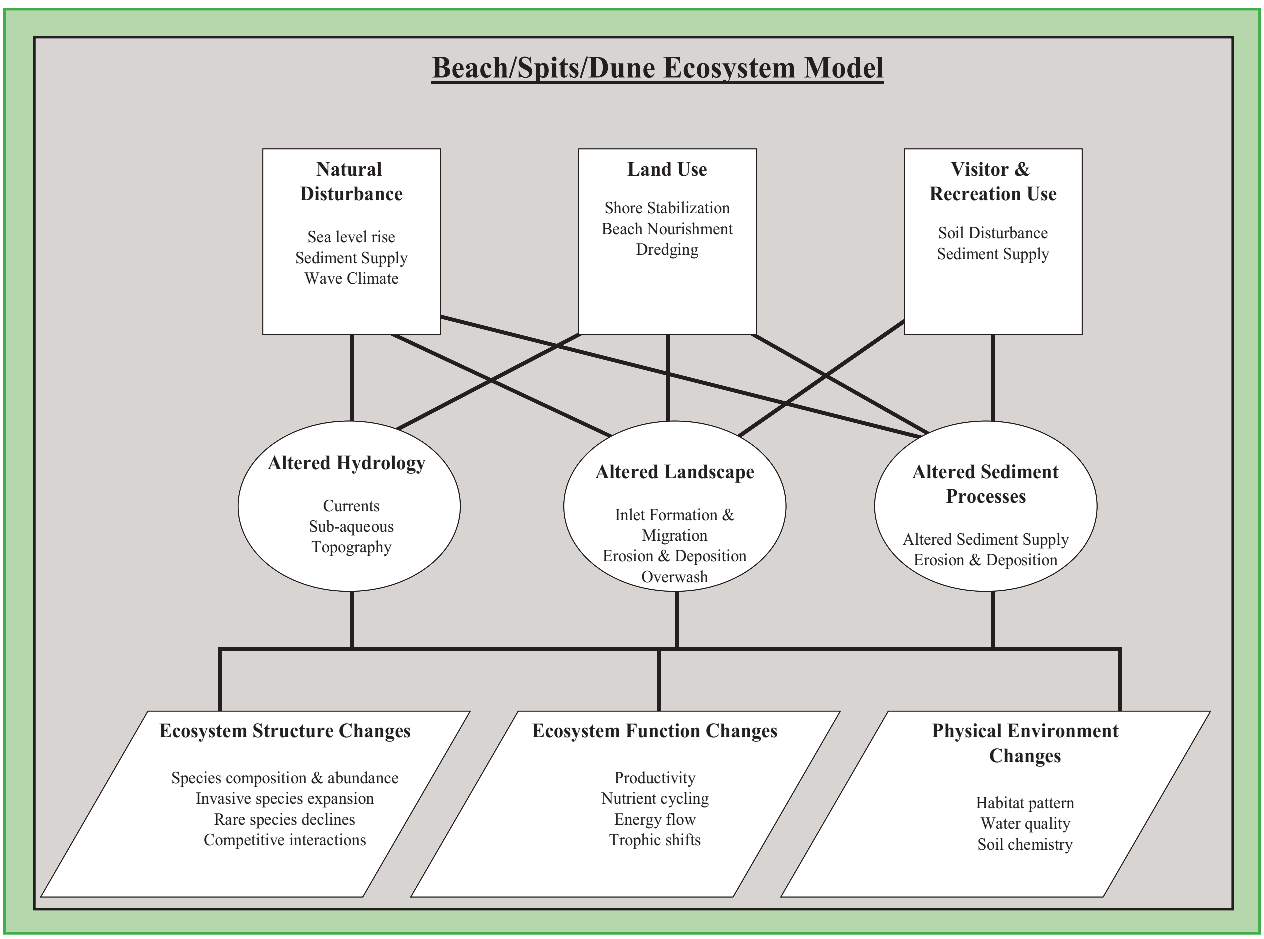

Figure 2.4. Northeast Coastal and Barrier Network beach/dune ecosystem conceptual model.
(Note: Squares=Agents of Change, Ovals=Stressors, Parallelogram=Ecosystem Responses)

Cape Cod National Seashore beach dune ecosystem.

magnitude and scope of the resultant ecosystem response is complex, highly variable, and often cumulative. For example, human-induced reduction in sediment supply can exacerbate local rates of natural shoreline erosion, creating a situation where part of the observed ecosystem response is natural and part is anthropogenic.

In general, the most immediate ecosystem response to stressors is a direct change in the physical environment. At the extreme, this includes the loss and/or gain of habitats, such as when coastal erosion creates new aquatic habitat at the expense of terrestrial or landscape-level reformation, which may occur during strong storms. More subtle physical responses also include changes in geochemical and hydrologic conditions, such as alterations in groundwater quality and quantity.

Ecosystem response in the beach/dune habitat can also be cascading. Stressor-induced changes in the physical environment often elicit secondary responses, such as changes in ecosystem structure or function. Structural responses, such as change in species composition or competitive interactions, generally reflect landscape-level alterations in the quantity and quality of specific habitat attributes. Similarly, functional responses such as changes in productivity or nutrient cycling may occur, often as a product of storm events and the associated reduction in habitat complexity.

Coastal Upland Ecosystem Model

Coastal uplands are transitional areas that experience strong gradients in environmental conditions across the shoreline inland interface. The physical features and biotic communities are structured largely according to these gradients. For example, the coastal edge of uplands requires the biota to tolerate wide ranging meteorological conditions and geomorphologic processes (salt spray, wind, sand deposition, large storm events). But in the more buffered and resource-rich inland areas, competition for resources is a more significant factor in the structuring of biotic communities. This results in an overall pattern of relatively narrow bands of strictly coastal upland communities, including those on dunes, which are in front of larger areas of forest, scrubland, or grassland whose structure and function is more like that of similar inland areas.

Coastal uplands are important for the retention of runoff waters, which decreases estuarine flooding and erosion and filters and removes pollutants before they reach coastal waters. Coastal uplands also are important for the stability of the water table, which affects the diffusion zone between fresh water and salt water environments. These areas also provide habitat for a variety of plant and animal species, and they can be particularly important for animals that utilize the shelter provided by upland areas as well as estuarine or marine food resources (See Figure 2.5).

Agents of Change

The NCBN conceptual model for coastal uplands ecosystems recognizes four agents of change: Natural Disturbance, Land Use, Resource Consumption, and Visitor and Recreation Use.

Natural Disturbances

Although uplands are probably the most buffered component of coastal systems, many natural processes still create disturbances that operate on both small and large spatial and temporal scales. Coastal areas are particularly susceptible to disturbance from extreme storm events, and the most powerful storms along the

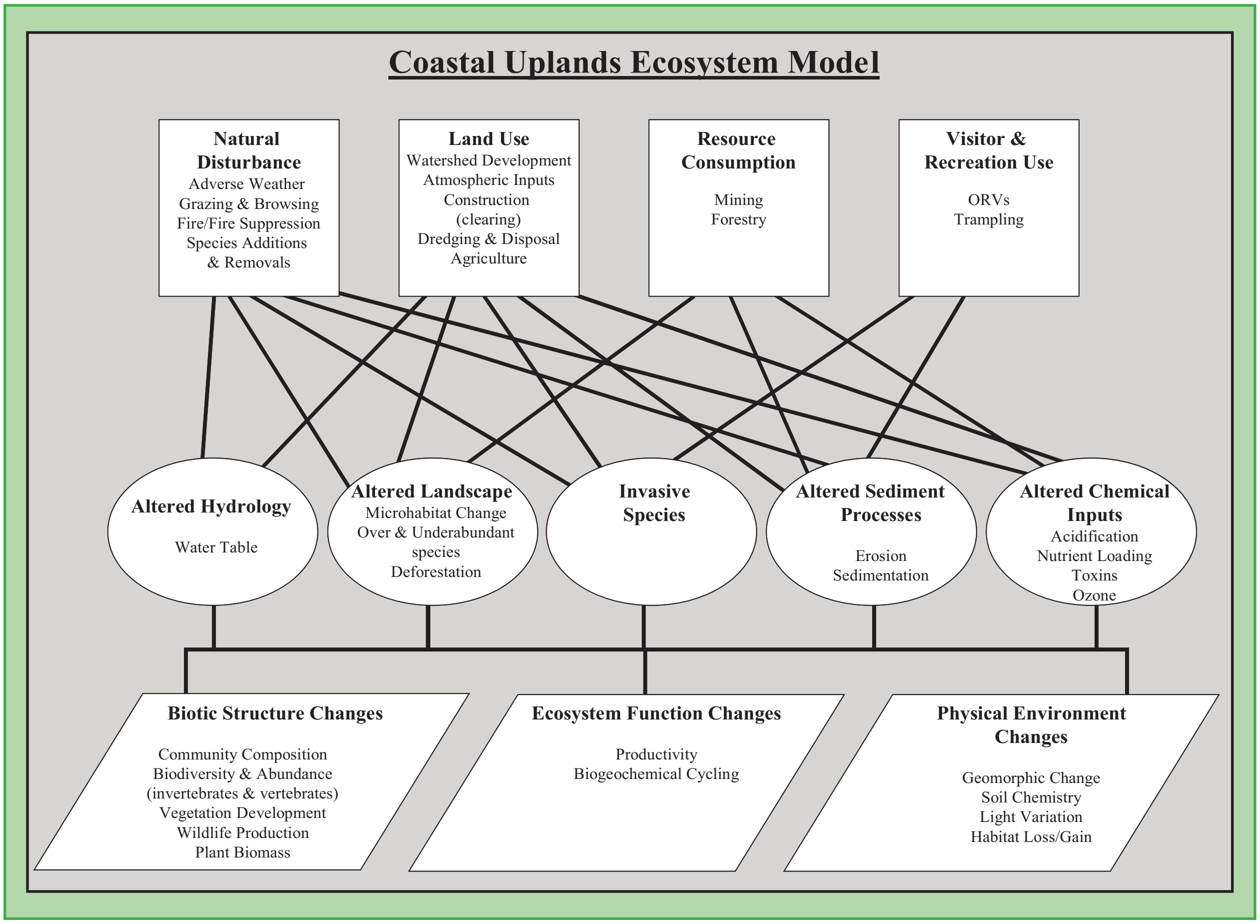

Figure 2.5. Northeast Coastal and Barrier Network upland ecosystem conceptual model.
(Note: Squares=Agents of Change, Ovals=Stressors, Parallelogram=Ecosystem Responses)

Atlantic coast of North America (hurricanes and winter "nor'easters") are fueled by open water, causing their strongest impacts along the immediate coast. Flood impacts occur from both ocean storm surge and inland fresh water runoff. These can create short or long term changes to hydrologic and superficial features. Flooding also changes soil and biotic conditions and processes through the transport of sediments and soils and the removal of vegetation. High winds from strong storms can create isolated or large scale blow downs of exposed trees.

Fire, whether generated by lightning or used by Native Americans as a landscape management tool, has always affected the structure and processes of Atlantic coastal upland ecosystems. Although historic fire cycles likely differ among NCBN park ecosystems, the last century of fire suppression throughout the region has changed the dynamics of all park ecosystems. In particular, areas that had adapted to frequent, low-intensity wildfires now have fewer early and mid-successional species and expanding shade-tolerant tree populations. The relative importance of fire is heightened when fire is suppressed, as longer living and more densely packed trees are more susceptible to insect and pathogen disturbance (Covington et al. 1994). Eventually, trees killed by drought, insects, or pathogens become fuels, increasing the likelihood of more intense, larger fires.

The introduction or removal of species by humans, whether purposeful or incidental, is another important agent of disturbance in these systems. Invasive plant species are now ubiquitous in upland areas, benefiting from gaps in vegetative cover created by disturbances. They quickly establish populations, which expand to create additional direct and indirect impacts on native plant and animal populations. Also, the removal of top predators from the highly populated coastal areas of the Northeast has direct and indirect effects on both animal and plant populations. Perhaps the most significant impact of predator removal has been the removal of white-tailed deer predators, resulting in an increase in deer populations.

Infection from pathogens, and grazing or browsing by animals, can alter the vegetation of coastal upland ecosystems. The abundance of white-tailed deer and their impact on the landscape is one example that has become a significant issue for many NCBN parks. Deer overpopulation can influence the presence, absence, and abundance of plants and other wildlife. In many forests, over-browsing of native shrub and tree seedlings leaves little or no ground cover except for species avoided by deer. One of these–the invasive Japanese barberry–can create virtual monocultures in deer-browsed areas.

Land Use

Northeastern coastal uplands are among the most heavily populated and developed areas in North America. Development within coastal upland watersheds and agricultural land uses alter the hydrologic properties, sediment processes, and chemical inputs of the uplands and adjacent estuarine or marine areas. Excessive nutrients and/or toxins in upland and adjacent areas lead to changes in plant and animal populations and to community structure.

Residential and commercial development increases the number of impervious surfaces. This can alter local and regional hydrologic properties by diverting runoff into storm sewers or natural drainages that may be adapted to lower flows. More intense and unpredictable flooding may result, destabilizing the water table and diffusion zone along the below ground fresh water-salt water interface.

Development increases the loss and fragmentation of natural habitats, stressing species with small populations, especially those that require large contiguous habitats, and ones that are intolerant of human contact. Ground disturbance associated with various land uses makes the invasion of exotic plant species more likely.

Resource Consumption

Forestry and groundwater extraction are agents of change in coastal upland areas. The wholesale removal of usable trees (for lumber and agricultural clearing) throughout the forests of the Northeast from the Colonial period through the 19th century caused dramatic changes to both coastal and inland ecosystems. The second and third-growth forests of uplands in the NCBN, and forests in surrounding park watersheds, are not active sites for logging. Probably the most significant resource we currently extract from coastal uplands is the groundwater we require for residential, commercial, and agricultural use. Excessive groundwater extraction can decrease freshwater input to estuarine ecosystems, thereby altering the movement and salinity of estuarine waters.

Visitor and Recreation Use

Coastal uplands in Coastal and Barrier Network parks are affected by park users both directly by the use and creation of trails and informal recreation sites, and indirectly by creating a need for park infrastructure development. For shoreline access, more social trails have been built in heavily used areas of Network parks. Even the use of trail-less areas–cliff tops and other sites with dramatic vistas, and shorelines–can degrade and fragment local habitats, altering hydrologic properties. Although park planning policies ensure that potential impacts are assessed before any in-park development occurs, heavy park use necessitates consideration for enhancements to park infrastructure.

<u>Stressors</u>

Altered Hydrologic Properties

Natural disturbances and differing land uses in coastal uplands can alter runoff, sediment transport, groundwater percolation, the water table, and the below ground interface between fresh and salt water.

Altered Landscape
Changes in land use, the direct consumption of resources, and natural disturbances can lead to changes in landscape patterns and processes. Past logging and recent fire suppression have likely been primary factors over the past centuries in the overall pattern of forest composition and cover. Habitat fragmentation in and around the NCBN parks continues to disrupt the distribution, abundance, and sometimes the persistence of native species, while allowing corridors of entry for invasive exotic species. Small scale changes often lead to critical changes in landscape.

Invasive Species
Exotic species are species in a new range which may not be rapidly spreading. Invasive species are rapidly spreading exotic species. In Northeast coastal uplands, most threatening invasive species are plants. Invasive plants in general are responsive to and responsible for changes in upland ecosystems. Many invasive plants have vegetative and reproductive characteristics (e.g., rapid growth, clonal growth habit, high seed production, and long distance seed dispersal) that allow them to take advantage of disturbances. When new to an ecosystem, many invasive species are free of the pathogens and consumers that plagued them in their native habitats. Lacking predators, they often outcompete native species, reducing plant diversity and the local and regional diversity of wildlife habitats. Some invasive plant species can change the landscape or its ecological processes in their new habitats. For example, they might create dense thickets in the forest understory or alter nutrient cycling in soils.

Altered Sediment Processes
Any changes to hydrologic properties or soils, whether short term, such as a storm event, or long term, such as changed land use or the development of a social trail, can alter the erosion and deposition of sediments, threatening plant and animal populations. For example, both eroding and depositional areas can become vectors for invasive species. Also, erosion of upland areas can alter the water quality and habitat value of adjacent freshwater or coastal wetlands.

Altered Chemical Inputs
Land uses (e.g., development and agricultural uses) alter the chemical inputs into coastal upland ecosystems. Acid precipitation, specifically sulfur dioxide and nitrogen oxides created from power generation and auto emissions, may already be changing forests throughout the Northeast by damaging the leaves of trees and leaching nutrients from soils. Local development and agricultural land use increases the amount of nutrients in soils, streams, and groundwater, thus increasing the likelihood of toxic chemical inputs. Manufacturing, commerce, and urban growth produce industrial chemicals, petroleum, pesticides, sewage, and combustion byproducts. Each of these threatens our ecosystems.

<u>Ecosystem Responses</u>

Ecosystem Function Changes
The primary productivity of plants in coastal uplands depends on available nutrients, nutrient cycling processes, and the composition of the upland biotic communities. Any agent of change or stressor to coastal uplands can alter one or more of these factors, disrupting productivity. For example, changes in local land use can increase nitrogen inputs into the system through runoff. Changes in regional land use can increase atmospheric deposition of nitrogen. However, changes in productivity in upland systems do not always reflect changes in the health of the ecosystem. For example, recently disturbed soils tend to release a large pulse of available nitrogen, which is often easily absorbed by fast growing exotic invasive species. In this case, the total productivity of the system increases in the short term, but other indicators (e.g., biodiversity) suggest a less healthy ecosystem.

Similarly, changes in biogeochemical cycling (the movement and transformations of materials in an ecosystem through biological, geological, and chemical processes and interactions) occur in response to stressors, but do not predict system health in a simple way. For example, fire suppression can alter nutrient cycling by changing the composition of forest floor materials from relatively more live plant matter and more exposed soils to relatively

Sandy Hook Unit of Gateway National Recreation Area, NJ overlooking New York City.

more dead plant material and more shaded soils. The soil microorganisms that mediate nutrient cycling are affected by the changed environment, and the processing of materials and release of nutrients slows when, for example, more large woody debris covers the forest floor. Changes in ecosystem functions usually co-occur with changes in biotic structure and the physical environment.

Biotic Structure Changes

Coastal uplands in the Northeast include numerous forest, shrub and meadow communities, and the birds, mammals, reptiles, amphibians, insects, and microorganisms that depend on these habitats for survival. Stress imposed on coastal uplands alters many aspects of the biological and ecological properties of these organisms. We can easily observe changes in plant growth, plant reproduction, and plant community composition. For example, the understories of many forests in the NCBN parks have been noticeably disturbed by human activities. Invasive exotic species have displaced many native plant species from their habitats.

Changes in the quality of wildlife habitat, whether through alterations to plant communities, land use changes, or other stressors, ultimately affect the composition of wildlife populations and communities. For example, declines in many amphibian populations can be associated with altered chemical inputs and changes to soil chemistry. The degradation of understory vegetation will likely disrupt forest songbird nesting and feeding behavior.

Physical Environment Changes

Many of the stressors to upland ecosystems can lead to changes in topography, hydrologic properties, soil composition, and other physical characteristics such as light conditions and air quality. These changes are reflected in measures of soil compaction along social trails, erosion and sedimentation in drainages, and light penetration to seedlings on a forest floor. These physical characteristics form the structure underlying the ecosystem. Therefore, changes to the physical environment will also be reflected indirectly by changes to biotic structure and ecosystem functions.

Freshwater Ecosystem Model

Only one of the eight parks in the Network–Cape Cod National Seashore–has significant freshwater areas, and these are being monitored as part of the Cape Cod monitoring program. Thus, few vital signs relating to fresh water ecosystems were prioritized as part of the Network monitoring program. A conceptual model depiction for this ecosystem type is included here and may be utilized in the further development of the Network or specific park monitoring program (see Figure 2.6).

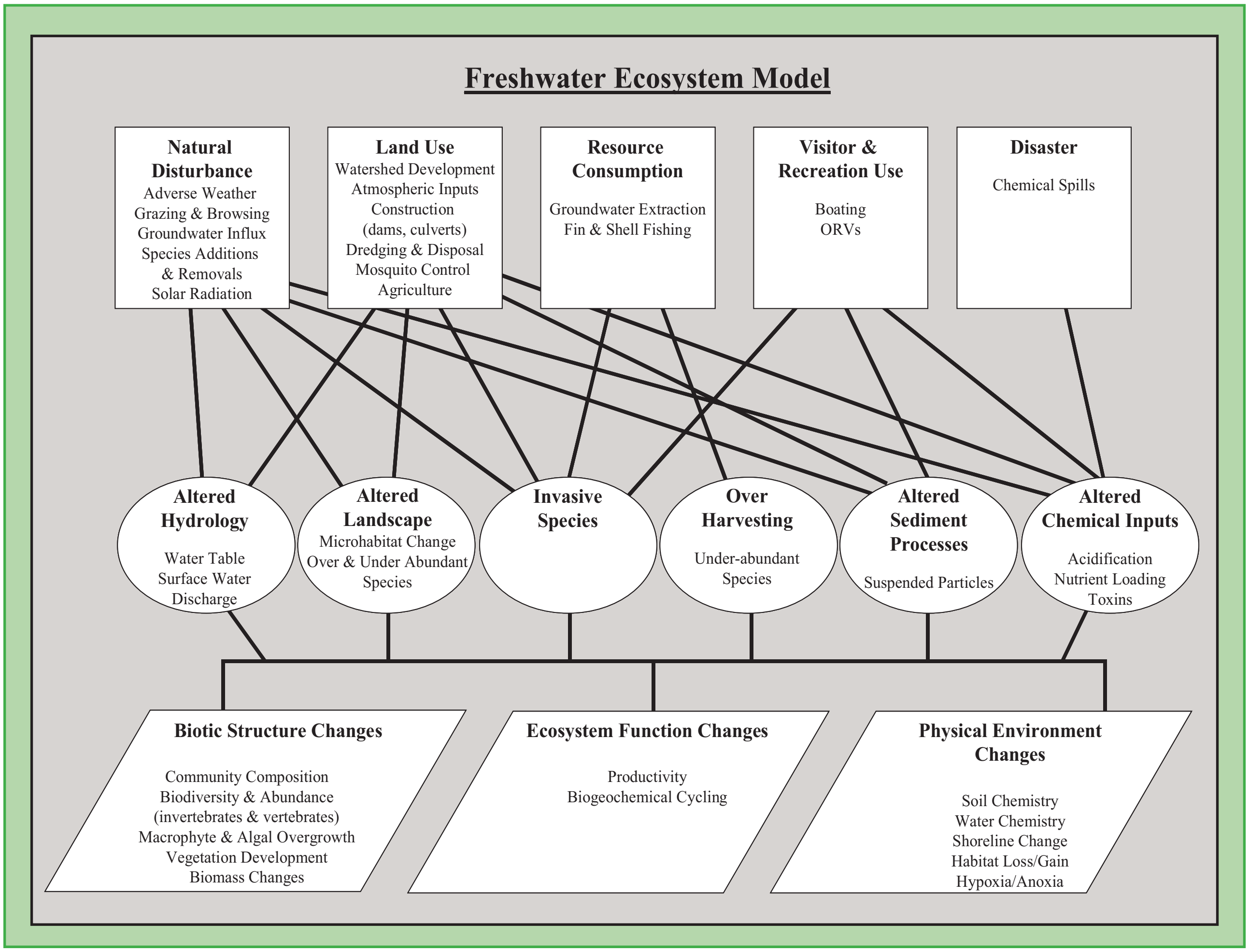

Figure 2.6. Northeast Coastal and Barrier Network freshwater ecosystem conceptual model. (Note: Squares=Agents of Change, Ovals=Stressors, Parallelogram=Ecosystem Responses)

Chapter 3 Vital Signs

"Even if a monitoring program is fully funded and implemented for many years, it will fail if the wrong candidate indicators (vital signs and measures) were selected. Thus the ultimate success or failure of the program may be determined by this one step." (Noon, 2003)

The intent of the National Park Service Vital Signs Monitoring Program is to track a subset of physical, chemical, and biological elements and processes of park ecosystems called "vital signs." These are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. Vital signs may occur at any level of organization including landscape, community, population, or genetic, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes). Because of the need to maximize the use and relevance of monitoring results for making management decisions, vital signs selected by parks may include elements that were selected because they have important human values (e.g., harvested or charismatic species) or because of some known or hypothesized threat or stressor/response relationship with a particular park resource.

The elements and processes that will be monitored as part of the NCBN Vital Signs Program are only a subset of the total suite that could be monitored to provide NCBN park managers with better data and information to make scientifically based management decisions. The Network's vital signs list has evolved over a number of years of data mining, identifying and prioritizing park critical issues, and reviewing important ecological processes occurring in the parks related to specific marine, coastal and terrestrial systems. The process taken by the Network to select its vital signs is described below and summarized in Figure 3.1.

Prioritization of NCBN Vital Signs

In 2000 the network held a vital signs scoping workshop to begin developing monitoring questions and lists of candidate vital signs and measures (see Chapter 1). The workshop was structured on the ecosystem-based framework developed for the Cape Cod National Seashore prototype monitoring program, one of the Network parks, as well as the prototype monitoring program for the Atlantic and Gulf Coast biogeographic region. This structure was based on four ecosystem types, eventually increased to five following the recommendation of the Network's Technical Steering Committee: *estuaries; salt marshes; freshwater wetlands; uplands; and beaches and dunes*. As the result of a long history of USGS and NPS collaborative meetings, well thought out lists of significant natural resource management issues were already available for Network parks. Five main issues were suggested by the Committee for providing further direction and structure to the vital signs workshop: *Shoreline Change; Water Quality; Species and Habitats of Concern; Resource Extraction; and Recreation and Visitor Use*.

Based on the work completed at the Network's vital signs workshop, reports from a number of issue-based working groups that convened following the workshop, and the development of conceptual models, the Network compiled its first list of candidate vital signs, monitoring questions and measures (see Table 1.2 and NCBN 2000a). Because this was an extensive list, and beyond the Network's capability to monitor due to funding constraints, the list of candidate vital signs needed to be refined and prioritized. The Technical Steering Committee recommended further development of the Network's monitoring program based on the original issues identified during the scoping workshop and the ecosystem-based structure. These include: *estuarine eutrophication* (formally called estuarine nutrients or as a more general term, water quality); *geomorphologic change* (formally shoreline change); *salt marsh change* (formally grouped with estuarine ecosystem monitoring); and *visitor use and impacts*, Also, the Committee added *landscape change* to address landscape-level issues related to all park ecosystems, but in particular, uplands (see Chapter 1). Within this framework, subject matter experts refined the list of candidate vital signs and these were jointly reviewed by the Network Technical Steering Committee and subject-matter experts. The feasibility of each vital sign and its measurability within a Network-wide program was reviewed individually along with its applicability to the Network's conceptual models.

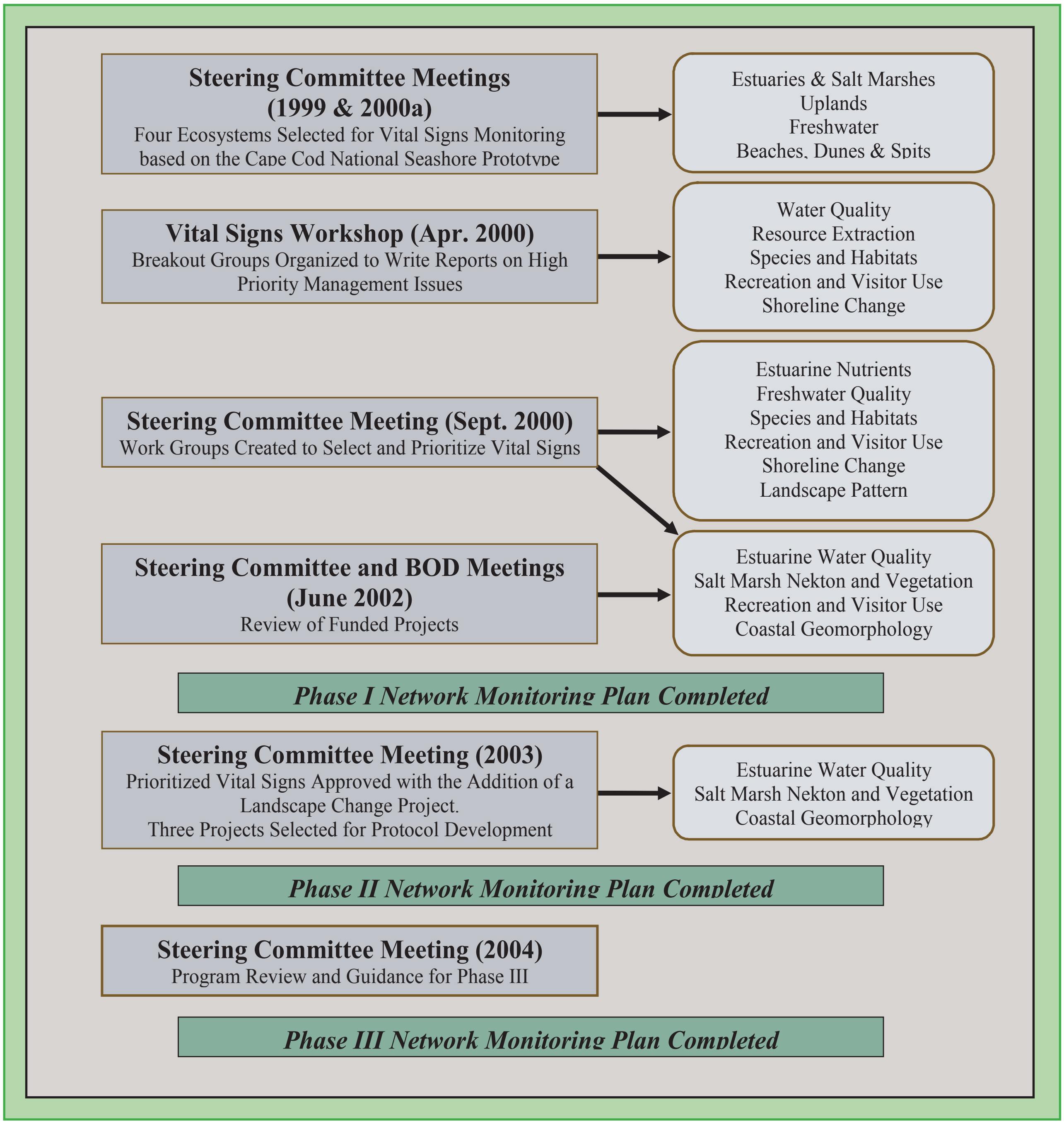

Figure 3.1. The NPS Northeast Coastal and Barrier Network Vital Sign identification and prioritization process.

NCBN Vital Signs and Measures

Both NCBN and Cape Cod National Seashore vital signs have been incorporated into the NPS Ecological Monitoring Framework. This national framework was developed as an organizational tool for promoting communication, collaboration, and coordination among parks, networks, programs, and agencies involved in ecological monitoring. All vital signs selected by parks and networks for monitoring are assigned to the Level 3 category that most closely pertains to that vital sign. For example, the NCBN vital sign "Ocean Shoreline Position" is assigned to the Level 3 category of "Coastal/oceanographic features and processes" within the Level 2 category of Geomorphology and Level 1 category of "Geology and Soils". The Level 1 categories will be used in a future "Natural Resource Report Card" to report on the condition of park resources. To promote collaboration among networks, a database has been developed using the framework to show which parks and networks will implement monitoring of vital signs within each Level 1, 2, and 3 category. The NCBN program includes four vital signs related to *biological integrity*, three related to *Landscapes*, four related to *geology and soils*, two related to *human use* and one related to *water*.

The prioritized list of NCBN vital signs is presented in Table 3.1. Following an independent process, the Cape Cod prototype selected additional vital signs to be monitored in their more intensive, park specific monitoring program. These are listed in Table 3.1 as well. Finally, some NCBN parks have existing long-term monitoring programs, vital signs associated with these park specific programs have been added to the table. These vital signs were included only if the park program is a long-term monitoring program, a program that has existed for a number of years and has plans to continue long-term.

The categories represented by the symbols in Table 3.1 provide information about who is developing protocols to monitor a particular vital sign, who will be funding the monitoring, and those vital signs that have been identified as important to the Network, but which cannot currently be implemented because of limited staff and funding.

The following sections describe the Network's vital signs organized by category: *estuarine eutrophication; salt marsh change; geomorphologic change; visitor use and impacts; and landscape change*. The general questions that led to the selection of these vital signs are provided. Many of the questions originated from the Network's vital signs workshop with little or no change, and others were developed and refined by subject-matter experts hired to assist in the prioritization of vital signs. These basic questions helped the network focus on specific issues and select vital signs and measures that would be both feasible to monitor network-wide, and provide the most information to answer the project questions.

NCBN Estuarine Eutrophication Vital Signs

- Are nutrient loads to park estuaries increasing?
- Are estuarine resources changing in response to nutrient inputs?
- What are the sources of nutrient enrichment?

Based on these questions, and the estuarine systems conceptual model (see Chapter 2)-which depicts the relationship between human activities, nutrient loading, and estuarine ecosystem responses-the network selected seven vital signs: *estuarine water chemistry; estuarine water clarity; estuarine water quality; estuarine sediment chemistry; estuarine nitrogen loading; seagrass distribution; and seagrass condition.* These seven vital signs fall into two ecosystem response categories within the model, physical environmental changes and changes to biotic structure. Categorized according to these seven vital signs, and based upon their ability to answer, the monitoring questions above, an exhaustive list of potential measures was then developed (Kopp *et al.* 2002).

Advantageous to the NCBN, an array of these measures had already been evaluated in some Network parks through extensive field testing to determine their suitability for long-term monitoring. Those

Table 3.1. Vital Signs to be or being monitored by the Northeast Coastal and Barrier Network (NCBN), the Cape Cod National Seashore Monitoring Program (CACO) and NCBN parks. Each vital sign has been categorized following the National Park Service Ecological Monitoring Framework.

Level 1	Level 2	Vital Sign	ASIS	CACO	COLO	FIIS	GATE	GEWA	SAHI	THST
Air and Climate	Air Quality	Air Contaminants	–	+	–	–	–	–	–	–
		Ozone	•	+	•	•	•	•	•	•
		Fine Particles	–	+	–	–	–	–	–	–
		Visibility	•	+	•	•	•	•	•	•
		Nitrogen/Sulfur Deposition	•	+	•	•	•	•	•	•
	Weather and Climate	Weather	•	+	•	•	•	•	•	•
Biological Integrity	Invasive Species	Exotic Plants	✧	✧	✧	✧	✧	✧	✧	✧
		Exotic Animals	•	✧	✧	✧	✧	✧	✧	✧
	Focal Species or Communities	Anurans	✧	+	✧	✧	✧	✧	✧	✧
		Salamanders	–	+	–	–	–	–	–	–
		Pond Vegetation	–	+	–	–	–	–	–	–
		Vernal Wetland Vegetation	–	+	–	–	–	–	–	–
		Land Birds	–	+	–	–	–	–	–	–
		Marsh Birds	✧	✧	✧	✧	✧	✧	✧	–
		Coastal Forest Vegetation (shrub/herbaceous layers)	–	+	–	–	–	–	–	–
		Coastal Forest Vegetation (trees)	–	+	–	–	–	–	–	–
		Meso-mammals	–	+	–	–	–	–	–	–
		Salt Marsh Nekton Community Structure	+	+	+	+	+	+	+	–
		Salt Marsh Veg. Community Structure	+	+	+	+	+	+	+	–
		Seagrass Condition	+	+	+	+	+	+	+	–
		Seagrass Distribution	•	•	•	•	•	•	•	–
		Coastal Heathland Vegetation	–	+	–	–	–	–	–	–
		Dune Grassland Vegetation	–	+	–	–	–	–	–	–
	At-risk biota	Piping Plover	•	•	–	•	•	–	–	–
Landscapes	Landscape Dynamics	Anthropogenic Modifications	+	+	+	+	+	+	+	–
		Landscape Change	+	+	+	+	+	+	+	+
	Productivity	Estuarine Sediment Chemistry	+	+	+	+	+	+	+	–
	Nutrient Dynamics	Estuarine Nitrogen Loading	+	+	+	+	+	✧	✧	–
Geology and Soils	Geomorphology	Coastal Topography	+	+	+	+	+	+	+	–
		Salt Marsh Sediment Elevation	+	+	+	+	+	✧	✧	–
		Shoreline Position	+	+	✧	+	+	✧	✧	–
		Offshore Topography	+	+	+	+	+	+	+	–
	Soil Quality	Estuarine Sediment Solid Phase Properties	–	+	–	–	–	–	–	–
Human use	Visitor and Recreation Use	Visitor Impacts	+	+	+	+	+	+	+	+
		Visitor Use	+	+	+	+	+	+	+	+

Table 3.1. Vital Signs to be or being monitored by the Northeast Coastal and Barrier Network (NCBN), the Cape Cod National Seashore Monitoring Program (CACO) and NCBN parks. Each vital sign has been categorized following the National Park Service Ecological Monitoring Framework (continued).

Level 1	Level 2	Vital Sign	ASIS	CACO	COLO	FIIS	GATE	GEWA	SAHI	THST
Water	Hydrology	Groundwater dynamics	–	✚	–	–	–	–	–	–
		Marine Hydrography	✚	✚	✚	✚	✚	✚	✚	–
		Surface water dynamics	–	✚	–	–	–	–	–	–
	Water Quality	Estuarine Water Chemistry	✚	✚	✚	✚	✚	✚	✚	–
		Estuarine Water Clarity	✚	✚	✚	✚	✚	✚	✚	–
		Ground-water Quality	–	✚	–	–	–	–	–	–
		Kettle Pond Acidification	–	✚	–	–	–	–	–	–
		Estuarine Water Quality	✚	✚	✚	✚	✚	✚	✚	–
		Ground-water Nitrates (estuarine input)	–	✚	–	–	–	–	–	–
		Kettle Pond Nutrient Loading and Eutrophication	–	✚	–	–	–	–	–	–

✚ High priority vital signs for which the network will develop protocols and implement monitoring using funding from the vital signs or water quality monitoring programs (shading indicates those being developed by the Network).
● High priority vital signs that are monitored by a network park, another NPS program, or by another federal or state agency using other funding. The network will collaborate with these other monitoring efforts.
✧ High priority vital signs for which monitoring will likely be done in the future, but which cannot currently be implemented because of limited staff and funding.
– Vital sign does not apply to park, or for which there are no foreseeable plans to conduct monitoring.
(Note: the shaded areas indicate those vital signs that the network is taking the lead on protocol development)

measures emerging as robust candidates were then considered candidates for extension to Network-wide monitoring of estuarine eutrophication. Additionally, potential measures arose following the consideration of estuarine characteristics within the Network parks, and of existing monitoring programs with relevance to estuarine eutrophication within the vicinity of these parks. Finally, each individual measure was evaluated in terms of its known characteristics for effective monitoring. Consequently, each variable was evaluated in terms of its relative contribution to a collective suite, with the goal of including representatives of different scales, trophic levels, and relationships to estuarine eutrophication.

Other considerations made in selecting measures was the efficiency associated with adopting uniform approaches from regional and national estuarine sampling across NPS programs and those of other federal agencies. Selected measures were evaluated for consistency with two NPS programs also under development (national water quality monitoring in marine/estuarine waters, NPS in prep; and water quality inventory protocols for estuarine/marine systems, Berounsky in prep.), and with the long-standing Environmental Monitoring and Assessment Program / National Coastal Assessment of the US Environmental Protection Agency (Jackson *et al.* 2000; US EPA 2001a). Thus, the final list of measures for network estuarine eutrophication monitoring, was influenced by both scientific and practical considerations.

Measures specifically associated with the estuarine nutrient inputs vital sign, were selected because these data are easily available from existing sources and analyses can be made on past, present, and future conditions.

NCBN Salt Marsh Monitoring Vital Signs

- Is salt marsh vegetation community structure changing over time (i.e. decades)?
- Is nekton community structure changing over time (i.e. decades)?
- Are salt marsh surface elevations changing over time, and if so, what factors are contributing to observed elevation changes?

Three vital signs have been identified for the salt marsh monitoring component of the NCBN vital signs program: *salt marsh vegetation community structure; salt marsh nekton community structure*; and *salt marsh sediment elevation change*. Because existing salt marsh monitoring protocols are being adopted by the Network, no vital signs or corresponding measurement selection was conducted by the Network, but rather directly adopted from these protocols (Raposa 2001a; Roman 2001;Cahoon 2004). These vital signs and corresponding measures are directly relevant to the Network's salt marsh conceptual model as presented in Chapter 2. Like the estuarine eutrophication vital signs, the salt marsh vital signs fall into two ecosystem response categories: biotic structure change (vegetation and nekton); and ecosystem function change (sediment elevation).

Geomorphologic Change Vital Signs

- What is the spatial and temporal variability in shoreline position?
- What is the spatial and temporal variability in dune/ beach topography?
- How do offshore topography and fundamental hydrodynamic processes affect changes in the beach/dune system?

The Network approach to developing a shoreline change program relies heavily on existing monitoring programs that are being developed for Assateague Island NS, Gateway NRA, Fire Island NS and Cape Cod NS Most of these programs involve GPS mapping of the shoreline. Recently, collaborative arrangements with Dr. Wayne Wright of NASA and Dr. John Brock of the USGS have allowed the Network to utilize aircraft based LIDAR (LIght Detection And Ranging) to gain a more detailed understanding of topographic changes to islands and beaches.

Information gained from existing programs, coupled with scoping to determine park needs, were evaluated in a series of workshops. The goals of these meetings included identifing key scientific issues, information gaps, and long-term data relevant to coastal geomorphologic change, as well as to identify vital signs and methods for monitoring geomorphologic change.

Workgroups composed of scientists, natural resource managers, and technical professionals from federal agencies, universities, and parks met at the following locations:

- USGS Patuxent Wildlife Research Center February 1999 (*Coastal Issues and Information Needs, A Summary of the Coastal Issues Symposium, USGS Patuxent 1999*)
- Gateway National Recreation Area April 2000 (NCBN 2000a) (NCBN 2001a)
- USGS Woods Hole Field Center January 2001 (*Report not available*)
- University of Rhode Island Coastal Institute October 2002 (NCBN 2003b)

The Gateway and Woods Hole workshops focused primarily on ocean shorelines and developed general feature categories for monitoring. The URI workshop, in addition to reviewing the results and recommendations of the previous meetings, also addressed the lower energy estuary issues and was much more exhaustive, detailed and specific regarding the identification of monitoring variables. The URI group went on to generate a lengthy list of potential variable indicators or vital signs and to prioritize them based on their feasibility of implementation at the network level and the value of information each might provide to park managers. Vital signs that gave good indications of the horizontal position of the shoreline and general beach and dune topography were selected for monitoring (see Table 3.1). Additional vital signs related to geomorphology, hydrography, and anthropogenic modification are also needed to better understand these processes.

Visitor Use and Impacts Vital Signs

- In areas of critical concern, how is the type, amount and distribution of visitor use changing over time?
- What types of activities (recreational or other) are occurring in parks and how are they changing over time?
- What are the management areas of critical concern where current or potential visitor activities threaten resource quality and compromise resource protection objectives?
- In areas of critical concern, what is the type and extent of visitor impacts to soil, vegetation and wildlife resources and how are these impacts changing over time?

Visitor use and impacts to coastal resources are a significant concern to resource managers in all Network parks. The degree of concern and the potential for significant impact, however, is highly area dependent. For example, Gateway National Recreation Area, located in the New York City metropolitan area, sees over eight million visitors per year, with many visitors engaged in traditional beach activities such as swimming, sunbathing, and sport fishing. In many cases, the popular sites for many of these activities are in proximity of areas managed for high resource protection. Conversely, at Sagamore Hill National Historic Site the majority of visitors stay within the museum facilities, with very little activity occurring on the trails and the small coastal area. Given these differences, the visitor impacts workgroup recommended that comprehensive scoping be completed for each park (see NCBN 2000a).

Individual scoping workshops and site visits were conducted for every park beginning in 2001. The goal of this work was to establish baseline conditions, review existing monitoring, and develop a list of candidate vital signs. This project consisted of two phases and two reports. The first report contains the information gathered during the individual park scoping meetings conducted by the cooperators assigned to this project (see Monz and Leung 2003a). The second phase and or report addressed selecting and prioritizing visitor use and impact vital signs for the Network (see Monz and Leung 2003b).

The scoping process revealed that park managers were most interested in measurements related to park use and this vital sign was ranked high in the prioritization process use in the Monz and Leung report. Both habitat alteration and wildlife disturbance were also ranked high as potential vital signs, however, it has been difficult to define measurements for these vital signs that could realistically be developed into monitoring protocols.

In 2004, the Technical Steering Committee reviewed these reports and the visitor use and impact monitoring project overall and indicated that further refinement was necessary before protocol development could begin (see NCBN 2004d). A workshop in January 2005 addressed this issue, reviewed the work already completed for this project, redefined the objectives and monitoring questions, and developed a scope of work for protocol development. Further refinement and protocol development will continue in 2006.

Landscape Change Vital Signs

- What are the landscape patterns (land cover and land use) within and around each park and how are these patterns changing over time?

The final vital sign, landscape change (Table 3.1), was proposed by the Technical Steering Committee. The Committee discussed the need for landscape change monitoring within parks and areas surrounding the network parks.

In 2003 the Network developed a cooperative agreement with Dr. Y.Q. Wang, director of the University of Rhode Island's remote sensing laboratory, to test the feasibility of using remote sensing techniques to map both terrestrial and marine aquatic vegetation within network parks. The project consisted of recreating the Fire Island National Seashore vegetation map classifications using remote sensing data and analyses. Final products for this project are due in the fall of 2005. The Network will present the results of this work to the Technical Steering Committee and Board of Directors for further input on the feasibility of using these methods to monitor landscape change.

In October 2003, following the identification of vital signs by other I&M networks, a list of vital signs common among networks was compiled nationally. Land use/land cover change was one of the most commonly selected vital sign by networks. Given the overwhelming interest, a National workgroup was created to explore ways to develop protocols for land use/land cover change. Dr. Y.Q. Wang, also participated in this effort. As a result, the Network decided to delay protocol development until the results of this workgroup and Dr. Wang's vegetation mapping project are complete. This decision was accepted by the Technical Steering Committee.

Vital Signs associated with Water Quality Monitoring

The Clean Water Act requires States to formally identify and publish all waters that do not meet water quality, or are not expected to meet water quality standards. The identification of these waters, officially defined as "water quality limited" is done through what is known as the "303d lists". Based on state, 1998 lists, two out of the eight parks in the NCBN were identified as having impaired waters, Fire Island NS and Gateway NRA. These park waters are estuarine waters, as are the majority of NCBN park waters. The principal impairments to these estuaries are those associated with nutrient enrichment, including dissolved oxygen, organic enrichment, and nutrients. To address the water quality component of the NPS Inventory and Monitoring Program, estuarine park waters will be monitored by the Network through the Network's estuarine eutrophication monitoring project (See Estuarine eutrophication vital signs section above).

Direct sampling within network park estuaries will provide information on ecosystem responses that are closely linked to nutrient levels and water quality. These are reflected in six vital signs; estuarine water chemistry; estuarine water quality; estuarine water clarity; seagrass distribution; seagrass condition; and estuarine sediment chemistry. A seventh vital sign, estuarine nitrogen loading, will provide estimates of past and present nitrogen discharge into park estuaries. These vital signs and their associated measures were recommended by a nationally organized workgroup established to provide assistance in identifying core water quality monitoring variables for marine and coastal parks. (NPS 2002a).

In addition to network estuarine eutrophication monitoring, the Cape Cod Prototype Monitoring Program includes additional vital signs monitoring related to impaired waters. Monitoring of nutrient inputs into marine, estuarine and freshwater areas occurs via groundwater nitrates and groundwater quality vital signs, as well as the air chemistry - nitrogen/sulfur deposition vital sign. Freshwater kettle ponds are also unique to Cape Cod NS, and monitoring of these ponds is ongoing through kettle pond acidification and kettle pond nutrient loading and eutrophication vital signs (Table 3.1).

Chapter 4 Sampling Design

The overall goal of the Northeast Coastal and Barrier Network sampling design is to ensure the cost-effective, collection of scientifically credible data with sufficient statistical power to allow inferences to be made on the condition of relevant park resources as defined by the monitoring objectives.

Introduction

This chapter describes the overall sampling design for the NCBN Vital Signs Monitoring Program. Elements covered include a discussion of the NCBN approach, a brief review of the statistical principles that guide the development of sampling design, and the details on why, where, and when samples will be collected for each monitoring protocol. At present (Sept. 2005), the estuarine eutrophication, salt marsh vegetation, and salt marsh nekton protocols are completing peer review. Because some protocols are still being reviewed, a discussion of sampling design issues to be addressed by the Network.

Sampling design development for the NCBN vital signs monitoring program began with the selection of vital signs within five key ecosystem types found in NCBN parks: estuarine, salt marsh, beach-spit-dune, upland and freshwater systems (see Chapter 1). For each of these five key ecosystems, the Network developed conceptual models to assist in our understanding of the dynamic relationships among ecosystem agents of change, stressors and responses (see Chapter 2). Through the development of these models, and identification of important resource management issues identified by each park, goals, objectives and monitoring questions (see Chapter 5) were developed to further guide the Network's Vital Signs Program. The Network's monitoring questions and objectives were to guide sampling design, to inform our understanding of the five ecological systems defined by the conceptual models.

Because the framework used to develop the NCBN monitoring program is both ecosystem and issue-based, the Network's overall sampling design can be viewed hierarchically. At the first level of design, all parks were stratified by these ecosystem types. Vital signs were chosen as indicators of the health of these coastal systems. At the second level, spatial sampling frames were developed specific to vital signs. Sampling will either occur park-wide, or by ecosystem; salt marsh, estuary, beach-spit-dune, freshwater systems, or uplands. At the simplest level, this ecosystem-based stratification determined the overall spatial design for the Network based upon whether or not those target populations (each ecosystem) exists in a park (see Table 4.1.).

The Network has initially focused on developing programs to monitor salt marsh, estuarine and beach-spit-dune ecosystems. Protocols for monitoring issue-based vital signs have been drafted, and are described below, along with sampling details provided in Table 4.2. At this time the Network has no programs specific to monitoring freshwater or upland ecosystems. Three programs in which park-wide sampling occurs are being developed that will include monitoring of these two systems. These include landscape change, visitor use and visitor impact monitoring. Further consideration will be given by Network staff and the Technical Steering Committee to monitoring vital signs specific to both freshwater and upland ecosystems.

Defining Monitoring Objectives

The NPS Inventory and Monitoring program has provided extensive guidance on how to develop sampling schemes, and extensive literature exists on survey sampling methods in science and commerce (e.g., Cochran 1977, Thompson *et al.* 1998). Sampling to obtain information on the current status of ecological resources is fundamental to monitoring,

Table 4.1. Northeast Coastal and Barrier Network park ecosystem types associated with each park.

Salt Marsh	Estuary	Beach	Freshwater	Upland
7 Parks	*7 parks*	*7 parks*	*8 parks*	*8 parks*
ASIS COLO FIIS GATE SAHI CACO GEWA	ASIS COLO FIIS GATE SAHI CACO GEWA	ASIS COLO FIIS GATE SAHI CACO GEWA	ASIS COLO FIIS GATE SAHI CACO GEWA THST	ASIS COLO FIIS GATE SAHI CACO GEWA THST

and the ultimate success of any monitoring program is directly tied to development of appropriate sampling designs that provide relevant information at appropriate temporal and geographic scales.

In a limited review by Reid (2001), it was shown that 13% of flawed monitoring programs failed due to problems associated with sampling. The process of sampling design involves deciding where, when, and how often to sample (Fancy 2000, Elzinga *et al.* 2001). All reasonable sampling programs must begin with clearly defined goals and objectives. Olsen (*et al.* 1999) noted that "Most of the thought that goes into a monitoring program should occur at this preliminary planning stage. The objectives guide, if not completely determine the scope of inference of the study and the data collected, both of which are crucial for attaining the stated objectives." Olsen goes on to say that a "clear and concise statement of monitoring objectives is essential to realize the necessary compromises, select appropriate locations for inclusion in the study, take relevant and meaningful measurements at these locations, and perform analyses that will provide a basis for the conclusions necessary for meeting the stated objectives."

The NCBN has spent considerable time developing monitoring objectives associated with each of its vital signs (see Chapter 5). Clear statement of objectives is the basis for good sampling design and protocol development. Review of these objectives will be ongoing as the development of the Network's program continues to grow and additional peer review specific to protocol designs are completed. There are two key questions that we considered when developing our monitoring objectives: at what spatial and temporal scales must monitoring occur in order to answer the monitoring question; and what is the scope of inference necessary to achieve the monitoring goal and question? Monitoring objectives must provide the basic criteria for developing the sampling design and by clear statement of the spatial scale, temporal frequency and the desired scope of inference, the sampling design can be developed.

Sampling Concepts and Terminology

Probability Sampling

Surveys are developed to provide information about some predefined population. If the population cannot be censused, a sample of items from the population is generally used to make inferences about the entire population. Surveys are usually grounded in probability sampling, in which the population (or the area in which the population occurs) is divided into sample units, each of which has a known probability of appearing in a sample. The actual samples chosen in the survey are selected randomly based on associated probabilities of selection, allowing development of sampling theory and estimates of population attributes. Collectively, the series of sample units is called a sampling frame, and in most sampling situations these units are spatially defined (i.e., the area in which a population occurs is divided into units that cover the entire area and samples are selected from those spatial units). If some items in the population have no chance of appearing in a sample, then inference from the sample does not extend to them i.e., the scope of inference does not include those items. The target population is the collection of items for which inference is desired.

Spatial Sampling Frames

Spatial sampling frames can be designed in a number of ways. For example, grouping items into discrete units that can be enumerated, such as a list of salt marshes or estuaries, is a common approach. These units can then be randomly selected using a variety of methods. Alternatively, an area of interest can be divided into contiguous cells (a grid), and samples can be selected from these cells. Often monitoring that uses remotely-sensed data collection methods, relies on a grid (pixel)-based sampling frame. Examples of this include the NCBN landscape change, seagrass distribution, and coastal topography vital signs (see Table 4.2). Sometimes the spatial sampling frame within a design includes the entire area of interest. An example of this occurs with the Network's ocean shoreline position monitoring (Duffy *et al.* 2005) in which all coastal shoreline within the parks are surveyed.

Although strongly discouraged, limited use of judgment sampling, the choice of representative sites based on "best professional judgment" is permitted in situations where logistical limitations preclude a probabilistic design or when existing programs with established sampling are incorporated into the Network's monitoring plan (Elzinga *et al.* 2001). In these rare cases, information gained will only be used to address specific questions about status, condition, or cause of change and inferences will be limited to the area sampled. In the NCBN salt marsh sediment elevation monitoring protocol for example, the Network will work with existing monitoring sites that have been established at Fire Island NS, Gateway NRA and Cape Cod NS. Additional sites to be added at Assateague Island NS and Colonial NHP will be collocated with salt marsh vegetation and nekton monitoring sites if adequate sites for the installations are present. The sediment elevation data will show how individual marsh sites are responding to sea level rise and will be useful in understanding the proximate factors affecting marsh loss or gain within those select marshes.

Temporal sampling frame

Choice of temporal sample frame for each vital sign depends on the scale of potential change, the monitoring objectives, and logistical concerns. Because we want to understand seasonal trends for some vital signs, such as ocean shoreline position and visitor use, the temporal scheme for these protocols includes measurement at least twice a year. In contrast, changes in vital signs such as landscape change, soil organic content, a measure associated with the estuarine eutrophication protocol, and seagrass distribution may take several years before any change is detectable. As a result, the temporal scheme associated with these vital signs will include monitoring at five to ten year intervals. A summary of when and how often samples are taken for each vital sign is presented in Table 4.2 and described in detail in each protocol. Again, the temporal design for all Network protocols is still under review and may be revised once initial pilot data are analyzed and peer review of the sample designs is complete.

Table 4.2. Summary of the spatial and temporal sampling design for the Northeast Coastal and Barrier Network Vital Signs Monitoring Program based on 2005 draft monitoring protocols.

Vital Sign	Design Element	Sampling Design Details
Shoreline Position	Target Population	The complete ocean shoreline in the park.
	Spatial Frame	• Sample Unit: the shoreline. • Selection Method: complete census of all spatial units. • Number of Units: not applicable. • Scope of Inference: entire park ocean shoreline.
	Temporal Frame	• Schedule: shoreline mapped twice a year and following major storms. • Scope of Inference: detects seasonal and long-term trends and the magnitude of episodic events.
Anthropogenic Modifications **Offshore Topography** **Marine Hydrography**	Target Population	Ocean and estuarine areas within or adjacent to park boundaries.
	Spatial Frame	• Sample Unit: all ocean and estuarine areas within or adjacent to park boundaries • Selection Method: complete census of all spatial units. • Number of Units: not applicable. • Scope of Inference: entire park.
	Temporal Frame	• Schedule: to be determined. • Scope of Inference: to be determined.
Coastal Topography	Target Population	All ocean and estuarine shorelines and adjacent habitats.
	Spatial Frame	• Sample Unit: $1m^2$ grids derived from Lidar data. • Selection Method: complete census of all spatial units. • Number of Units: not applicable. • Scope of Inference: entire park.
	Temporal Frame	• Schedule: to be repeated every 2-6 years. • Scope of Inference: detects multi-year trends.
Salt Marsh Nekton Community Structure **Salt Marsh Vegetation Community Structure**	Target Population	All salt marsh areas within park boundaries for FIIS, SAHI, GEWA, & ASIS; target population reduced to specific areas of management concern for CACO, GATE, & COLO.
	Spatial Frame	• Sample Unit: nekton are sampled in pools or ditches at each salt marsh Site. Vegetation is sampled in $1m^2$ plots along transects at each salt marsh site. • Selection Method: site selection varies by park: for SAHI and GEWA a single salt marsh site is available; a stratified random design is used for FIIS and ASIS (based on distance to inlets); sites at CACO, GATE, & COLO chosen based on management needs of the parks (this decision is currently being reviewed). Within sites pools and ditches are randomly selected for nekton sampling using a combination of grid, transect, and randomized lists. For these same sites, vegetation plots are located at fixed distances along uniformly spaced transects with random starting locations. • Number of Units: the number of sample units was determined by power analysis. • Scope of Inference: entire park for FIIS, SAHI, ASIS, & GEWA; inference restricted to sampled marshes for CACO, GATE, & COLO.
	Temporal Frame	• Schedule: each park sampled every three years. • Scope of Inference: detects multi-year trends in the summer nekton and vegetation communities.

Table 4.2. Summary of the spatial and temporal sampling design for the Northeast Coastal and Barrier Network Vital Signs Monitoring Program based on 2005 draft monitoring protocols (continued).

Vital Sign	Design Element	Sampling Design Details
Salt Marsh Sediment Elevation	Target Population	All salt marsh areas within park boundary.
	Spatial Frame	• Sample Unit: three sediment elevation tables (SET) per marsh. • Selection Method: SETs are established in at least two marsh sites per park. Established SETs exist in FIIS, GATE and CACO. Additional sites to be collocated with Salt Marsh Nekton and Vegetation monitoring in COLO & ASIS. • Number of Units: existing protocol with power analysis used to determine optimal sampling effort. • Scope of Inference: methods used to choose site locations will need to be evaluated to determine scope.
	Temporal Frame	• Schedule: sediment elevation measurement recorded three times a year. • Scope of Inference: detects both seasonal and long-term trends.
Estuarine Sediment Chemistry **Estuarine Water Chemistry** **Estuarine Water Clarity** **Estuarine Water Quality**	Target Population	All estuarine waters within park boundary for FIIS, SAHI, GEWA, & ASIS. For CACO, GATE, & COLO the largest estuaries are chosen.
	Spatial Frame	• Sample Unit: points. • Selection Method: a grid of 30 tessellated hexagons is overlain on the study area and a single sample point is randomly chosen from each hexagon. Six points identified as permanent trend stations to be re-visited each sample period; the remaining 24 points will be re-randomized at the start of every sample period. To complement the spatial survey water chemistry, clarity, and quality measurements will be taken continuously at a single representative site. • Number of Units: the number of sample units chosen determined by established EPA protocols. • Scope of Inference: entire park for FIIS, SAHI, ASIS, & GEWA; inference restricted to sampled estuaries for CACO, GATE, & COLO. Inference from continuous samples restricted to single site and data are used for interpretation of spatial surveys.
	Temporal Frame	• Schedule: sediment chemistry is measured every five years at the 6 trend sites and the current 24 randomized points. The remaining vital signs are sampled annually. The 24 randomized points are sampled once and the six trend sites are sampled weekly during a four-week summer index period. Continuous monitoring will occur concurrently at single fixed site. • Scope of Inference: detects multi-annual trends in sediment chemistry and annual changes in water chemistry, clarity, and quality. Continuous sampling provides information on diel variation in water measurements during the index period at a single site.
Seagrass Condition	Target Population	A single seagrass bed is chosen to represent defined characteristics necessary for the protocol.
	Spatial Frame	• Sample Unit: 0.25m^2 plots along a 50-m transect. • Selection Method: twelve 0.25m^2 plots randomly located along three transects stratified by depth (shallow, mid-depth, and deep). • Number of Units: the number of sample units chosen determined by established protocols. • Scope of Inference restricted to surveyed bed.

Table 4.2. Summary of the spatial and temporal sampling design for the Northeast Coastal and Barrier Network Vital Signs Monitoring Program based on 2005 draft monitoring protocols (continued).

Vital Sign	Design Element	Sampling Design Details
Seagrass Condition	Temporal Frame	• Schedule: sampling occurs four times a year initially; may be reduced to once a year. • Scope of Inference: detects annual changes in the condition of a single bed.
Seagrass Distribution	Target Population	All seagrass beds within or adjacent to the Park boundary.
	Spatial Frame	• Sample Unit: detectable seagrass beds. • Selection Method: complete census of all seagrass beds that can be detected with aerial photography. • Number of Units: not applicable. • Scope of Inference: entire park.
	Temporal Frame	• Schedule: mapping repeated at least once every five years during peak growth period. • Scope of Inference: detects multi-year changes.
Estuarine Nitrogen Loading	Target Population	The entire watershed for all park estuaries.
	Spatial Frame	• Sample Unit: the watershed. • Selection Method: complete census of all model parameters that can be gathered for the watershed. • Number of Units: not applicable. • Scope of Inference: estuarine waters within or directly adjacent to the park boundary.
	Temporal Frame	• Schedule: analysis to be completed once every 10 years. • Scope of Inference: detects decade level changes.
Visitor Impacts **Visitor Use**	Target Population	Protocol in planning stage but will target all areas of the park including terrestrial, freshwater, and marine ecosystems.
	Spatial Frame	• Sample Unit: To be determined. May be points, transects, or pixels. • Selection Method: to be determined. May stratify based on known use (backcountry vs. front country). Number of Units: to be determined. • Scope of Inference: entire park.
	Temporal Frame	• Schedule: to be determined. • Scope of Inference: to be determined.
Landscape Change	Target Population	Protocol in planning stage but will target all areas of the park including terrestrial, freshwater, and marine ecosystems.
	Spatial Frame	• Sample Unit: detectable land use / land cover classes. • Selection Method: complete census of all spatial units. • Number of Units: not applicable. • Scope of Inference entire park.
	Temporal Frame	• Schedule: to be repeated every 5-10 years. • Scope of Inference: detects multi-year changes.

Ecosystem-based Designs

Salt Marsh Monitoring

Within NCBN park salt marshes, the Network will be collocating vegetation, nekton and sediment elevation monitoring within the same sampling sites (marshes). This component of the sampling design includes 7 Network parks (see Table 4.1 above). In developing a salt marsh monitoring program, the Network chose to adapt existing protocols. These protocols, developed for the Cape Cod NS monitoring program had salt marsh restoration objectives. Review of the adapted draft NCBN protocols, both vegetation and nekton, do not meet the Network's monitoring or sampling objectives. Salt marsh site selection was conducted on an individual park basis and need. Network staff will be revisiting this design along with a contracted statistician in the fall, 2005, and revising the protocols as necessary to insure adequate inference to target populations.

The salt marsh sampling design as it exists is based on a stratified design for Fire Island NS and Assateague NS. Salt marsh selection at Assateague was based on management issues associated with feral horse distribution on the island. Salt marsh site selection at Fire Island NS was based on a marsh's distance to an inlet. For Gateway NRA and Colonial NHP, site selection was based upon accessibility, size of the marshes and current management needs. For George Washington Birthplace NM and Sagamore Hill NHS, marsh areas were small enough to sample the entire area. As described here, the current selection of sampling sites, a key element in the design, is variable across the Network. The Network will be revising this design to better suit the objectives of the program. This will require developing specific criteria for site selection of salt marsh throughout the Network, allowing for a more uniform design than indicated in our draft protocols.

Vegetation Sampling

Currently, the sampling frame for the vegetation component of the salt marsh monitoring program includes dividing each selected marsh site into sections and randomly locating one transect in each section. All transects are oriented perpendicular to the main elevation gradient of the marsh (*e.g*., from tidal creek to upland). If no elevation gradient is apparent or if there is no defined tidal creek, transects traverse the marsh from upland to upland. One meter^2 vegetation plots are positioned along transects with the first plot randomly located within the first 10 to 40m of the transect. All subsequent plots are located systematically along the length of the transect at pre-determined intervals (*i.e*., 10m, 20m, 30m, *etc*.). The interval between adjacent plots is dependent on the length and the total number of transects per marsh. The systematic division of the area with the random placement of transects and randomization of the first plot within each transect provides better interspersion of samples within the sample area. A minimum of 20 replicate, permanent, 1m^2 vegetation plots, are sampled at each study site, and selected marshes will be sampled every three years.

Nekton Sampling

For the nekton component of the Network's salt marsh monitoring program, open water habitats (e.g., creeks, pools, and mosquito ditches) are sampled within the selected marshes. Within each marsh, pools and larger tidal creeks (>1m wide) are sampled using throw traps. Power analyses on existing data have indicated that at least 15 replicates should be sampled. If there are fewer than 15 pools on the marsh, then all pools are sampled, and if there are more than 15 pools, then at least 15 are randomly selected and sampled. Locations of stations along shoreline areas and larger tidal creeks are randomly located along the length of the shoreline. Ditch nets are also used to sample grid ditches and smaller tidal creeks (<1m wide) of salt marshes. At least 10 ditch nets are sampled per marsh, and are randomly located along the length of the ditch or tidal creek.

Nekton sampling will occur twice per year, once in early summer (after June 15) and in late summer-early fall (August to early October), every three years.

Sediment Elevation Sampling
Sediment elevation monitoring is based on a draft protocol developed for the Cape Cod NS monitoring program (Cahoon *et al.* 2004). This protocol will be reviewed and adapted for Network monitoring. Currently, sediment elevation monitoring is being conducted at Fire Island NS, Gateway NRA and Cape Cod NS. These sites were established prior to the development of the Network's salt marsh monitoring program, however, data from these sites will be used by the Network as part of the salt marsh program. Additional sites will be established by the Network at Assateague NS and Colonial NHP collocated with the vegetation and nekton sampling sites. Sampling will occur three times each year at all sites.

Estuarine Monitoring

Sediment chemistry, water chemistry, water clarity, water quality, and seagrass monitoring sites will be collocated in NCBN park estuaries. This component of the sampling design includes 7 Network parks (see Tables 4.1 and 4.2). The estuarine sampling design includes a number of spatial components including: complete surveys, probabilistic sampling and judgment sampling. Again, like the Network's salt marsh monitoring program, the goal in monitoring estuarine health in Network parks is to develop a sampling plan that provides the greatest scope of inference and characterizes the condition of all park estuarine systems. The draft estuarine eutrophication protocol will undergo rigorous statistical review to assure the sampling design meets this goal and the specific monitoring objectives (see Chapter 5). Like salt marsh site selection, the existing estuarine site selection described in the Network's draft protocol (Kopp and Neckles 2004) is being reviewed. Questions have been raised by reviewers related to the site selection methods described in the draft protocol, and the current scope of inference. These will be addressed by the principal investigators who developed the protocol, in collaboration with Network staff.

Water Chemistry, Water Clarity, Quality and Sediment Organic Carbon Sampling
Spatial sampling of estuarine water chemistry, water quality, water clarity, and estuarine sediment organic carbon uses a probability-based systematic survey design (Figure 4.1). The sampling framework for each park consists of a grid of tessellated hexagons that encompass the estuarine area of interest. Grids contain 30 hexagons, and sampling occurs at a random location chosen within each hexagon. The number of hexagons was determined based on the known spatial variability of vital sign measurements and the desired degree of change detection (see Kopp and Neckles 2004).

The temporal component of this design includes measurements occurring weekly during a four-week summer index period each year, and the estuarine sediment chemistry survey occurring every five years at 24 random and 6 fixed stations for trend analysis.

Because many of the estuarine eutrophication vital signs are known to exhibit a high degree of temporal variability, with important events occurring more frequently than weekly sampling may detect, continuous water quality data will also be collected. These data will compliment data collected as part of the overall probability-based design used for monitoring water quality, water chemistry, water clarity and sediment organic chemistry. One representative site has been chosen at each park for continuous water quality monitoring. Stations are selected to be representative of the overall estuary they are placed in. Because these data are not part of the probability design, they will not be used to make inferences beyond each sampling station, but will be used to help interpret results from the probability-based data.

Seagrass Sampling-Condition
Like the continuous water quality sampling described above, the sample design for monitoring seagrass condition follows a similar judgment-based design. A representative SAV bed is selected in each park and within-bed measures of seagrass condition, including percent cover, shoot density, canopy height, and areal biomass, are sampled using a cluster sampling

Figure 4.1. Northeast Coastal and Barrier Network Estuarine Eutrophication protocol sampling framework using a grid of tessellated hexagons over Colonial National Historical Park, VA.

design stratified by depth zone. One 50-m transect is randomly located within each of three depth zones (shallow, mid-depth, and deep). Twelve sampling locations are then randomly positioned along each transect. Sampling occurs within and adjacent to 0.25-m^2 plots, and plots are revisited at least annually. This sample design is based upon the design developed as part of the Global Seagrass Monitoring Network (http://www.seagrassnet.org/). Critics of this design believe it should be probabilistically-based, in order to make inferences to all park seagrass beds.

Seagrass Sampling-Distribution

In order to monitor seagrass distribution within the Network parks, a complete census of all detectable seagrass beds will be conducted at least once every five years. Seagrass distribution measures include the size, location, and structure of submerged aquatic vegetation (SAV) beds within each Network coastal park. All detectable SAV beds will be mapped within park boundaries from aerial photographs. Measurements follow the national data standards for benthic habitat mapping (Finkbeiner *et al.* 2001).

Beach-Spit-Dune Monitoring

The Network will be monitoring ocean shoreline position and coastal topography. The draft ocean shoreline position protocol is available on the Network's website (Duffy *et al.* 2005). The Network has been working through cooperative agreement with

USGS scientists working collaboratively with NASA scientist to develop methods for monitoring coastal topography. A protocol will be developed for the Network in 2007.

Based on the draft protocol, ocean shoreline position will be monitored in 4 of the Network parks and will include a complete census of all spatial units (see Table 4.2). In order to track seasonal variation, shoreline surveys will be conducted on a twice per year basis and timed to capture the general occurrence of the maximum seasonal (winter/summer) state. The winter shoreline position will be collected in mid-March to late April and the summer shoreline position in mid-September to late October in each of the parks.

Future NCBN Program Development

Four additional protocols are also being developed by the Network: visitor impacts, visitor use, estuarine nitrogen loading, and landscape change. In the fall, 2005, the Network will be entering into an agreement with a contracted statistician to carefully review, revise and rewrite as necessary, all NCBN protocol sampling designs. Each protocol's monitoring objectives, spatial and temporal sampling designs, sampling objectives and approaches to statistical analyses, will undergo this extensive review. This will include all draft protocols as well as elements of those scheduled for completion by 2008 (see Chapter 9, Table 9.1). The overall goal in developing the sampling design for the Northeast Coastal and Barrier Network is to ensure the cost-effective, collection of scientifically credible data with sufficient statistical power to allow inferences to be made on the condition of park resources as defined by our monitoring objectives.

Chapter 5 Monitoring Protocols

Monitoring protocols are detailed study plans that explain how data are to be collected, managed, analyzed, and reported, and are a key component of quality assurance for natural resource monitoring programs. Protocols are necessary to be certain that changes detected by monitoring actually are occurring in nature and not simply a result of measurements being taken by different people or in slightly different ways. . . . A good monitoring protocol will include extensive testing and evaluation of the effectiveness of the procedures before they are accepted for long-term monitoring. Peer review of protocols and revisions are essential for their credibility. The documentation should include reviewers' comments and authors' responses. (Oakley *et al*. 2003)

Following selection of vital signs and existing protocols, the Network began to develop new protocols for monitoring. Protocols developed by the NCBN will outline a process 1) for collecting information on a vital sign, and 2) for determining how that information will be managed, analyzed and reported. All protocols developed by the Network will be detailed enough to ensure that changes detected by monitoring truly occur in nature and aren't the result of measurement variability introduced when different people or methods are involved (Oakley *et al*. 2003).

Introduction

Each NCBN protocol includes (Table 5.1) a detailed *narrative* that contains a summary of its history, from protocol design through development, including policies or decisions that are relevant to the protocol. This will allow the protocol to develop more efficiently and ensure that it will not be a repetition of previous trials or comparisons (Oakley *et al*. 2003). The narrative also includes a list and brief summary of all *Standard Operating Procedures* (SOPs), which are developed in detail as independent sections or documents.

SOPs delineate how to accomplish each procedure required by the protocol. At minimum, the SOPs address pre-sampling training requirements and preparation, data to be collected and collection techniques, data management, data analysis, reporting, equipment operations, and any activities required at the end of a field season (e.g., equipment storage). Each of the Network's protocols will also include an SOP that identifies guidelines on when and how the protocol will be revised, along with a revision log. Since SOPs are stand alone documents, this allows revision of specific procedures to occur without having to revise the entire document.

Table 5.1. List of sections included in all Northeast Coastal and Barrier Network monitoring protocol narratives and SOPs.

- justification for vital sign selection
- monitoring goal, questions and objectives
- sampling design (including spatial and temporal sample design)
- field methods
- data management
- data analysis and reporting
- staffing requirements
- training procedures operational requirements

Protocol Organization and Summaries

The NCBN has identified ten protocols for the development and implementation phase of the program. These ten protocols address 18 vital signs. These protocols will be developed and implemented within the next few years. All other vital signs described in Chapter 3, Table 3.2 of this plan may or may not be added to the implementation list, depending upon the availability of funding.

As of 2005, NCBN has four draft protocols completed. These protocols describe monitoring: salt marsh vegetation (James-Pirri and Roman 2004a); nekton (James-Pirri and Roman 2004b); shoreline change (Duffy *et al.* 2005); and estuarine eutrophication (Kopp and Neckles 2004). These four protocols are currently in the peer review phase. Once this phase is complete, the principal investigators associated with each protocol will make revisions based on comments from reviewers. Draft versions of these protocols are available on the Network's website and links to each are available in Chapter 11-Literature Cited of this plan under each primary author.

Six other protocols are planned for development in 2006-2007. These protocols will address monitoring: salt marsh sediment elevation; coastal topography; estuarine nutrient inputs; visitor use; visitor impacts; and landscape change. A summary of each protocol is included in this chapter. Table 5.2 lists NCBN parks targeted for protocol implementation.

All protocols are developed as stand-alone documents, and are detailed beyond the scope of this report. However, a complete summary of their development is presented in Chapter 9, Table 9.1. A Protocol Development Summary (PDS) for each protocol. is available. Links to each are included Chapter 11 under NCBN 2005a-j. Protocol Development Summaries

Table 5.2. Northeast Coastal and Barrier Network Inventory and Monitoring Program protocols, vital signs, and parks targeted for monitoring.

Protocol	Vital Sign	Park							
		ASIS	CACO	COLO	FIIS	GATE	GEWA	SAHI	THST
Ocean Shoreline Position	Shoreline Position	X	X		X	X			
Coastal Topography	Anthropogenic Modifications	X	X	X	X	X	X	X	
	Offshore Topography	X	X	X	X	X	X	X	
	Marine Hydrography	X	X	X	X	X	X	X	
	Coastal Topography	X	X	X	X	X	X	X	
Salt Marsh Nekton	Salt Marsh Nekton Community Structure	X	X	X	X	X	X	X	
Salt Marsh Vegetation	Salt Marsh Vegetation Community Structure	X	X	X	X	X	X	X	
Salt Marsh Elevation	Salt Marsh Sediment Elevation	X	X	X	X	X			
Estuarine Eutrophication	Estuarine Sediment Chemistry	X	X	X	X	X	X	X	
	Estuarine Water Chemistry	X	X	X	X	X	X	X	
	Estuarine Water Clarity	X	X	X	X	X	X	X	
	Estuarine Water Quality	X	X	X	X	X	X	X	
	Seagrass Condition	X	X	X	X	X	X	X	
	Seagrass Distribution	X	X	X	X	X	X	X	
Estuarine Nitrogen Loading	Estuarine Nitrogen Loading	X	X	X	X	X			
Visitor Impacts	Visitor Impacts	X	X	X	X	X	X	X	X
Visitor Use	Visitor Use	X	X	X	X	X	X	X	X
Landscape Change	Landscape Change	X	X	X	X	X	X	X	X

include a justification for the selection of each vital sign and its associated measurable indicators, along with a description of the sampling approach and schedule.

Monitoring Goals, Questions, and Objectives to be addressed by each Protocol

Ocean Shoreline Position

Justification: Coastal ecosystems are dynamic environments driven by numerous natural and anthropogenic agents of change. Sea-level rise, sediment supply, and wave climate are the primary natural disturbances that drive geomorphologic change. These variables influence coastal geomorphologic response at temporal scales that include individual events (storms), cyclic variations (seasonal), and multi-year (long-term) trends. The effects of the long-term trend of sea-level rise cause an inland displacement of the shoreline. When coupled with erosion produced by a prevailing sediment deficit, the result is an increased shoreline displacement (National Research Council 1987; Warrick 1993). Whereas, sea-level and sediment supply are the primary general factors, wave climate is the principle agent that steers the local sediment transport and consequently controls the site-specific shoreline configuration (Tranhaile 1997).

The problem of land loss/gain and landscape alteration at the marine edge is fundamental to many issues facing coastal park resource stewards. The two geomorphologic protocols will generate a wide range of data on shoreline and coastal features, which will improve our understanding of the processes that drive coastal change. Shoreline position is a prime indicator of coastal environmental resource threats within parks. Change in shoreline position drives the alteration and replacement of established natural habitats, and shoreline retreat may destroy cultural resources, facilities, and other infrastructure.

In addition to global, regional, and local natural causes, many cases of coastal erosion are accelerated by human perturbations to the natural system. Specific changes to tides, waves, currents, and availability of sediment generate profound morphologic and ecosystem feedback. Examples range from stabilized inlets, seawalls, and groins, to hardened shorelines for inland protection, and beach and dune rebuilding with added sand from an external source. Habitat and ecosystem responses to such changes are not well understood by ecologists.

Typical beach/dune ecosystem found at Assateague Island National Seashore, Maryland/Virginia

Substantial shoreline retreat is also driven by aperiodic storms (tropical cyclones in summer and mid-latitude nor'easters in the winter). Storm effects upon the beach may be ameliorated within a week or two but if the system is degraded, a decade of storm quiescence may be needed for recovery.

Easily implemented at the park and network level, ocean shoreline position monitoring will yield valuable data to managers. The data assembled can be quickly and effectively incorporated into park management operations and decision making.

<u>Vital sign</u>:
Shoreline position

<u>Monitoring Goal</u>:
To improve the understanding of and provide information to park managers on the dynamic nature of coastlines, including the spatial and temporal patterns

of change in NCBN parks for use in management decisions and describing the condition of marine and coastal areas.

Monitoring Question:
What is the spatial and temporal variability in shoreline position?

Monitoring Objectives:
Determine long-term trends in the seasonal and annual variability in shoreline position for the ocean shoreline in Network parks.

Characterize and improve understanding of how long-term trends in marine hydrodynamic processes (tide, current and wave), offshore topography (sediment quality, bathymetry and location of migrating shoals and bodies) and the location of man-made structures influence NCBN park beach/dune systems.

Measures:
Shoreline position

Once peer review is complete and revisions made, the completed NCBN Ocean Shoreline Position protocol will be available on the Network's website, a draft is currently available (See Duffy *et al.* 2005 in the Literature Cited) . The Protocol Development Summary for Coastal Shoreline Position is also available (see NCBN 2005a).

Coastal Topography

Justification: Compared to ocean shoreline position, landscape features and patterns at the inland reach of wave domination are less variable indicators of changes in coastal morphology. As a result, significant changes and trends associated with these features are more easily detected and applied to park management decision making. Dune, cliff, and bluff erosion and migration often involve direct threats to resources, buildings and infrastructure, and even to human safety, and are a major management issue in many parks. Over wash fans and flood plains serve as indicators of potential change and can provide early warning to park managers of an impending issue or of a need for additional monitoring and research. Changes in coastal topographic features may also indicate changes in habitat that require management action.

Photo taken from the air of Fire Island National Seashore, New York.

Vital signs:
Coastal topography, offshore topography, marine hydrography, anthropogenic modifications.

Monitoring Goal:
To improve the understanding of and provide information to park managers on the dynamic nature of coastlines, including the spatial and temporal patterns of change in NCBN parks for use in management decisions and describing the condition of marine and coastal areas.

Monitoring Questions:
What is the spatial and temporal variability in dune/beach topography?

How do offshore topography and fundamental hydrodynamic processes affect changes in the beach/dune system?

Monitoring Objectives:
Determine trends and characterize the variability in beach-dune topography of the ocean coastline in

Network parks over seasonal, annual, and long-term scales.

Characterize and improve understanding of how long-term trends in marine hydrodynamic processes (tide, current and wave), offshore topography (sediment quality, bathymetry and location of migrating shoals and bodies) and the location of man-made structures influence NCBN park beach/dune systems.

Measures:
Dune, cliff, bank features, shore type, over wash fans/flood plain, landscape pattern, edge of vegetation, bathymetry, location of migrating shoals and bodies, sediment size and type, current patterns, sea level position, tide range, wave characteristics, locations of jetties, shoreline armoring, dredge channels, beach nourishment sites, dune manipulations

This protocol is due to be completed in 2007. Once peer review is completed, the NCBN Coastal Topography protocol will be available on the Network's website. The Protocol Development Summary for Coastal Topography monitoring is currently available (see NCBN 2005b).

Salt Marsh Nekton

Justification: Salt marsh ecosystems provide both important habitat and essential ecological services in NCBN parks. Salt marshes are among the most biologically productive ecosystems on earth, providing nursery grounds for recreational and commercial fishes among other species that are integral to the estuarine trophic food web. They provide habitat for endemic salt marsh plants and migratory shorebirds and water birds. Salt marshes buffer coastlines from erosion and reduce nutrient inputs to estuarine and coastal ecosystems by filtering land-derived runoff.

The three Network protocols specific to Salt Marsh monitoring–Salt Marsh Nekton, Salt Marsh Vegetation, and Salt Marsh Elevation–will help managers track changes to multiple resources simultaneously. These will, in turn, help uncover mechanisms for understanding the processes that may be affecting salt marshes in specific parks as well as in the region.

Nekton (defined as free swimming fishes and crustaceans) are an abundant estuarine fauna that provide an integral link between primary producers, consumers, and top predators. They are likely to respond to either top-down or bottom-up estuarine perturbations. For example, nutrient enrichment (a bottom–up perturbation) could affect nekton by altering submersed vegetative habitats that serve as nursery grounds. Conversely, removal of predatory fishes through over-fishing (top-down) could induce responses in the forage or prey nekton. Nekton also represent a significant portion of the diets of many fish-eating birds, economically valuable fishes, and (in estuaries) marine mammals.

Monitoring nekton over time will help evaluate both natural and human-induced changes in estuarine nekton over the long-term and will advance our understanding of the interactions between nekton and the dynamic salt marsh and estuarine environment. Additionally, through long-term monitoring, the presence or emergence of invasive species of nekton will be detected and their subsequent impact on nekton community dynamics can be evaluated.

Vital sign:
Salt marsh nekton community structure

Monitoring Goal:
To monitor salt marsh and estuarine ecosystem condition in NCBN parks in order to provide managers with information to make better informed management decisions and to work more effectively with other agencies and individuals for the benefit of these park resources.

Monitoring Questions:
Is nekton community structure (species composition, abundance, and size structure) changing over time?

Monitoring Objectives:
Determine long term trends in species composition, abundance and size structure in nekton communities

in selected NCBN park salt marshes.

Measures:
Species composition, size structure, abundance

Once peer review is complete and revisions made, the final NCBN Salt Marsh Nekton protocol will be available on the Network's website. The draft protocol is currently available (see James-Pirri & Roman 2004b in the Literature Cited). The Protocol Development Summary for Salt Marsh Nekton monitoring is also available (see NCBN 2005c).

Salt Marsh Vegetation

Justification: Salt marsh communities are sensitive to disturbance and perturbations from natural causes such as storms and geomorphic processes, as well as human induced impacts associated with nutrient loading, watershed development, tidal restrictions, and ditching. There is a long history of alteration of salt marshes along the Northeast coast, including extensive ditching for mosquito control, salt hay farming, and restriction of tidal exchange by roads, causeways, bridges, and dikes. As the coastal corridor becomes more urbanized, watersheds become increasingly developed. Salt marsh acreage declines and becomes fragmented. Urbanization leads to increased air pollution, intensified recreational use of coastal areas, and an increase in septic and sewer systems, which leads to nutrient-laden runoff.

By monitoring Salt Marsh vegetation, the Network will be able to provide information to park managers on how park salt marsh communities are changing over time. Detection of species composition change, including the presence of invasive species can provide early warning to park managers that changes in pollution levels, salinity levels, tidal flow and groundwater levels may be occurring within or around the park.

Vital sign:
Salt marsh vegetation community structure

Typical salt marsh ecosystem found at Fire Island National Seashore, New York.

Monitoring Goal:
To monitor salt marsh condition in NCBN parks in order to provide managers with information to make better informed management decisions and to work more effectively with other agencies and individuals for the benefit of these park resources.

Monitoring Questions:
Is salt marsh vegetation community structure (species composition and abundance) changing over time?

Monitoring Objectives:
Determine long term trends in species composition and abundance in salt marsh vegetation in selected NCBN park salt marshes.

Measures:
Percent cover, species composition, abundance

The draft NCBN Salt Marsh Vegetation protocol (see James-Pirri & Roman 2004a in the Literature Cited) is currently available. Once peer review is complete and revisions made, the final protocol will be available on the Network's website. The Protocol Development Summary for Salt Marsh Vegetation monitoring is available (see NCBN 2005d).

Salt Marsh Sediment Elevation

Justification: The mean elevation of salt marsh surfaces must increase to keep pace with the annual rise in sea level and subsidence of salt marsh organic substrates. If the sedimentation rates in a salt marsh do not equal or exceed the net loss in elevation due to the steady increase in sea level and salt marsh subsidence, it will "drown". When a salt marsh "drowns", the surface of the marsh becomes sub-tidal which can cause drastic habitat changes such as the conversion of vegetated salt marsh to unvegetated mud flat.

As recognized in the CACO 1999 Conceptual Framework (Roman and Barrett 1999), understanding changes in relative salt marsh elevation is important for interpreting changes in salt marsh vegetation communities and other estuarine ecosystem components. Salt marsh erosion and accretion are also important parameters for measuring the response of formerly impounded marshes to restoration of tidal influence, and will be particularly critical if the rate of sea level rise accelerates as predicted.

In addition to monitoring sediment elevation changes in NCBN salt marshes, this project is also part of a worldwide effort to monitor sea level rise with sediment erosion tables (SETs) (Boumans and Day 1993) and cryogenic coring devices (Cahoon *et al.* 1996). These two techniques measure the amount of erosion and accretion on salt marsh surfaces.

<u>Vital sign</u>:
Salt marsh sediment elevation

<u>Monitoring Goal</u>:
To monitor salt marsh condition in NCBN parks in order to provide managers with information to make better informed management decisions and to work more effectively with other agencies and individuals for the benefit of these park resources.

<u>Monitoring Questions</u>:
Are salt marsh surface elevations changing over time, and if so, which factors are contributing to observed elevation changes (e.g., surface versus subsurface processes, sediment accretion rates)?

<u>Monitoring Objectives</u>:
Determine long term trends in salt marsh elevation at selected sites in NCBN parks and factors contributing to the observed changes (sediment deposition or erosion).

<u>Measures</u>:
Relative elevation, sediment accretion

This protocol is being developed for the Cape Cod National Seashore Prototype Monitoring Program, but has been adopted by the Network for implementation in five of the Network's parks. The Cape Cod National Seashore Salt Marsh Sediment Elevation protocol (Cahoon 2004) is currently under review. The Protocol Development Summary for Coastal Salt Marsh Sediment Elevation monitoring is currently available (see NCBN 2005e in the Literature Cited).

Estuarine Eutrophication

Justification: Approximately one quarter of the NPS jurisdicted land area within the Northeast Coastal and Barrier Network is submerged. These estuaries, bays, and lagoons serve as islands of relatively pristine aquatic habitat within the Northeastern urban corridor. The North Atlantic coastal parks are dependent on high-quality aquatic resources to sustain the complex estuarine and near-shore ecosystems they represent.

Diverse threats to NPS estuaries include natural disturbances (e.g., storms, sea-level rise), direct impacts of human activities (e.g., dredging, shellfishing, fishing, boating, dock construction), indirect effects of watershed development, and disasters. Park managers throughout the Network have repeatedly identified threats to coastal water quality as one of their highest priority management issues. Much of the watershed area of NPS coastal ecosystems lies outside protective park boundaries and is subject to intense developmental pressures. Jurisdictional issues surrounding submerged resources in migrating parks are sometimes unclear. Therefore, there is great potential for human disturbances to coastal watersheds, resulting in increased nutrient loading to park estuaries.

The ecosystem indicators of Estuarine Nutrient Enrichment protocol will directly measure several water quality indicators.

Vital signs:
estuarine water chemistry, estuarine water quality, estuarine water clarity, estuarine sediment chemistry, seagrass distribution, seagrass condition

Monitoring Goal:
Provide information to NCBN park mangers on the status and trends of park estuarine water quality for use in management decisions and contribute to understanding and describing the condition of marine and coastal areas.

Monitoring Questions:
Are nutrient loads to park estuaries increasing?
Are estuarine resources changing in response to nutrient inputs?
What are the sources of nutrient enrichment?

Monitoring Objectives:
Determine long-term trends in summertime levels of dissolved oxygen concentration, turbidity, attenuation of photosynthetically active radiation, temperature, salinity and suspended chlorophyll concentrations in estuarine waters and organic carbon in estuarine sediment in selected NCBN park sites.

Determine the distribution and abundance of submerged aquatic vegetation beds in selected areas in NCBN parks.

Determine long-term, inter-annual trends in seagrass condition (shoot density percent cover and biomass) in selected estuarine areas of NCBN parks.

Measures:
Dissolved oxygen, temperature, salinity, chlorophyll a, photosynthetically active radiation (Par), turbidity, percent organic carbon of surficial sediments, sav bed size, structure and location, sav within bed: percent cover, shoot density, biomass.

This protocol was developed to compliment the EPA's Coastal Assessment Program as well as the park-based, water quality monitoring program at Assateague Island NS.

The Draft protocol and Protocol Development Summary for Estuarine Eutrophication monitoring is currently available (see Kopp and Neckles 2004; NCBN 2005f in the Literature Cited).

Estuarine Nitrogen Loading

Justification: Nitrogen from land-derived sources is delivered to estuaries in surface and ground water flow. Quantifying actual loads of nitrogen requires spatially and temporally intensive measurement of stream and groundwater flux and nutrient concentrations (e.g. Doering *et al.* 1995; Nielsen 2002), and is beyond the scope of a regional monitoring program. However, the human activities contributing to increased nitrogen delivery to coastal waters are well documented and are trackable at the landscape scale.

While it would be most desirable to obtain direct measures of nutrient inputs, in particular, nitrogen (N), to the estuarine waters of the Northeast Coastal and Barrier Network parks, such an effort may not prove to be sustainable over the long term. Surface discharges are event driven and therefore difficult to predict and sample adequately. And while the field collection of surface waters for nutrient analyses is relatively straightforward, acquiring representative ground water samples is technically difficult. The laboratory facilities and staff required to carry out the analytical work for nutrient analyses are probably not within the financial or human resources of most of the parks. For these reasons, a protocol is being developed by the Network to monitor estuarine nutrient agents of change, or potential sources of nitrogen within the watersheds of each of the parks. These proxy indicators will include such things as: human population numbers, permitted water withdrawals for agriculture, fertilizer consumption, and land use. Remaining questions that arise from monitoring and modeling may be answered through focused research.

Vital sign:
Estuarine nitrogen loading

Monitoring Goal:
Provide information to NCBN park mangers on the status and trends of park estuarine water quality for use in management decisions and contribute to understanding and describing the condition of marine and coastal areas.

Monitoring Questions:
What are the sources of nutrient enrichment to park estuaries?

Monitoring Objective:
Determine long-term trends in nitrogen loading estimations to NCBN park estuaries through nitrogen load modeling that incorporates human population density, atmospheric, fertilizer and wastewater nitrogen sources, non-point source discharge permits, permitted water withdrawals for domestic and agricultural consumption, fertilizer consumption and livestock population data.

Measures:
Nutrient point source discharge permits, livestock populations, fertilizer consumption, permitted water withdrawals for domestic and agricultural consumption, wet deposition chemistry.

This protocol is in the initial stages of development. The Network expects its completion in 2006-2007. The Protocol Development Summary for Estuarine Nitrogen Loading is currently available (see NCBN 2005g in the Literature Cited).

Visitor Use

Justification: The parks of the Northeast Coastal and Barrier Network are located in a heavily populated region, and park resources are potentially impacted by

Great Kills Swimming Beach at Gateway National Recreation Area.

large numbers of visitors and in-park and near-park residents, as well as in-park and near-park resource consumption activities such as fin and shell fishing. The Network Technical Steering Committee identified park user impacts as one of five key management issues, and this has been supported by park staff throughout project development.

Recreational and other park use levels and impacts are a concern in all park habitats, from upland forests and fields to eroding coastal bluffs, estuarine marshes, and near shore open water habitats. Common park uses include hiking, dog walking, and bicycling on official and social trails, off road vehicle driving on beaches and backcountry areas, fin and shell fishing, boating with motorboats, canoes and kayaks in estuarine and marine areas, and park based maintenance, interpretation, and resource management activities.

Park managers must have documentation of the full range of activities occurring within their parks, how many people are doing each activity, and where these activities are occurring, as well as information on the changes in these activities over time, in order to understand the linkages between the condition of resources and specific park uses of concern. These data can also provide some indication of how changes in park management are reflected in park uses of natural areas.

The visitor impact vital sign is associated with direct impacts to park landscapes that are associated with park use and can also be quantitatively measured and mapped. These measurements will allow for a quantifiable link between park use and resource impacts and allow for the tracking of trends in these impacts over time, and therefore should assist park managers in making decisions regarding resource protection and sustainable park uses.

Vital sign:
Visitor use

Monitoring Goal:
Provide information to NCBN park managers that will lead to a better understanding of park visitor use patterns and intensity.

Monitoring Questions:
In areas of critical concern, how is visitor use changing over time?

What types of activities (recreational or other) are occurring in parks and how are they changing over time?

Monitoring Objectives:
Determine both the seasonal and long-term trends in the distribution and abundance of visitors and associated activity types in NCBN parks.

Measures:
Distribution and abundance of visitors, distribution and abundance of activity type.

This project has gone through a number of stages. Two reports were written for the Network based upon data mining efforts in the Network parks related to visitor use and impacts (Monz and Leung 2003a and 2003b). These reports were products of a cooperative agreement the Network had developed with two recreation scientists, Dr. Yu-Feu Leung, North Carolina State University, and Dr. Christopher Monz, Sterling College, working collaboratively. At the same time, Cape Cod National Seashore entered into an interagency agreement with USGS scientist Dr. Jeff Marion, to develop a similar protocol to monitor visitor use and impacts in the prototype park.

In order to bring together the work that the Network had completed and the work that was being completed for CACO, the Network held a meeting in January 2005, at Gateway National Recreation Area. Scientists, park staff, prototype park staff and network staff discussed what elements of the previously funded work, would be used in a Network-wide monitoring protocol. With this meeting, specific vital signs and measures were agreed upon, and as a result a more manageable approach to visitor use and impact monitoring was outlined. The Network will work closely with CACO staff in drafting a protocol to be completed in 2006-2007. The Protocol Development Summary for visitor use is currently available (see NCBN 2005h in the Literature Cited).

Visitor Impacts

Justification: Based on site visits and manager interviews, visitor impacts were found to be a significant threat and management concern at the majority of NCBN parks (Monz and Leung, 2003b). Major network-wide impact commonalities include trampling vegetation and soils, wildlife disturbance, impacts related to off-road vehicle use, and trash. Park specific impact problems and monitoring needs were identified through dialogue with staff in each park.

High visitation within NCBN parks creates the potential for significant and widespread impacts to natural resources and processes. As recreation is a legitimate use of parks, the issue for managers is at what level do resource impacts become unacceptable based on other park management mandates and objectives. Visitor impacts frequently occur at initial or low levels of use, and result in substantial resource changes in localized areas (Hammitt and Cole 1998). Such impacts can decrease the functionality of facilities like trails and recreation sites, increase safety concerns, reduce aesthetic enjoyment and contribute to visitor displacement, create conflict between visitor groups, and increase management costs (Marion and Farrell 1998).

Recreation activities can cause impact to all resource elements in an ecosystem. Soil, vegetation, wildlife and water are four primary components that are affected (Marion and Cahill 2003). Because various ecological components are interrelated, recreation impact on a single ecological element can eventually result in effects on multiple components (Hammitt and Cole 1998).

Vital sign:
Visitor impacts

Monitoring Goal:
Provide information to NCBN park managers on visitor impacts to park natural resources that will lead to improved knowledge and management of these resources and the prediction and prevention of further impacts.

Monitoring Questions:
What are the management areas of critical concern where current or potential visitor activities threaten resource quality and compromise resource protection objectives?

In areas of critical concern, what is the type and extent of visitor impacts to soil, vegetation and wildlife resources and how are these impacts changing over time?

Monitoring Objectives:
Monitoring objectives have not been determined.

Measures:
Specific measures have not been determined.

Up until this point, visitor use and visitor impact monitoring have been treated jointly in the data mining and initial reporting phase of the NCBN program. Two reports were written for the Network based upon data mining efforts in the Network parks related to visitor use and impacts (Monz and Leung 2003a and 2003b). These reports were products of a cooperative agreement between the Network and two recreation ecologists, Dr. Yu-Fai Leung, North Carolina State University, and Dr. Christopher Monz, Sterling College, working collaboratively. At the same time, Cape Cod National Seashore entered into an interagency agreement with USGS scientist Dr. Jeff Marion, to develop a similar protocol to monitor visitor use and impacts in the prototype park.

For protocol development ease, the Network will be developing two separate visitor resource protocols, one to monitor visitor use and activity patterns using social science related methods, and one to monitor visitor impacts on park natural resources. The Protocol Development Summary for visitor impacts is currently available (see NCBN 2005i in the Literature Cited).

Landscape Change

Justification: Landscapes are ecological systems that exist at the scale of kilometers and comprise recognizable elements such as salt marsh, estuaries, forest patches, heathlands, as well as human settlements. Landscape change as defined by the Network, includes both "land cover" and "land use" change. The term land cover will be used by the Network to refer to types of naturally occurring vegetation or classes of vegetation. Land use will be used to describe and refer to alterations to the landscape by humans. The primary goal of this protocol will be to monitor landscape change based on land use and landcover classes that can be distinguished by remote sen sing. Both terrestrial and sub-tidal environments within and around all of the Northeast Coastal and Barrier Network (NCBN) parks will be monitored. All NCBN parks have identified landscape change monitoring as an important and necessary tool for future management practices.

Vital sign:
Landscape change

Monitoring Goal:
Monitor landscape change in and around NCBN parks and provide synthesized information on landscape

change and dynamics to park managers for their use in decision making and natural resource conservation and protection.

Monitoring Questions:
What are the landscape patterns (land cover and land use) within and around each park and how are these patterns changing over time?

Monitoring Objectives:
Determine long-term trends in spatial and temporal patterns of landscape change in and around NCBN parks using remotely sensed imagery.

Measures:
Specific measures have yet to be determined.

In 2003, the Network developed a cooperative agreement with remote sensing scientist, Dr. Y.Q. Wang, at the University of Rhode Island. Dr. Wang was tasked with determining the most cost efficient methods for monitoring landscape change using remotely sensed data. This project will be completed in the fall of 2005. Based upon the NCBN results and the progress by a nationally based remote sensing workgroup created to recommend protocols for monitoring land use and land cover, further efforts by the Network to identify potential partners in the development of a full monitoring protocol, a project will be developed in FY2006 to complete or collaborate on a monitoring protocol. A Protocol Development Summary for visitor use and impact monitoring has been developed by the Network and is currently available (see NCBN 2005j in the Literature Cited).

Chapter 6 Data Management

As the basic and most important products of scientific research, data and other forms of information represent a valuable and often irreplaceable resource (Michener and Brunt 2000). Field experiments and associated data collection are time consuming and expensive. Thus, effective data and information management is essential for the success of any long-term ecological monitoring program, and the NCBN Inventory and Monitoring Program's highest priority will be to create and maintain high quality data and data documentation.

To that purpose, the NCBN has developed a draft Information Management Plan (Stevens and Entsminger 2004) that describes the Network's information management infrastructure (e.g., staffing, hardware, software) and architecture (databases, procedures, archives). The plan is available on the Network's website at http://www1.nature.nps.gov/im/units/ncbn/index.htm. This plan includes procedures to ensure that relevant natural resource data collected by NPS staff, cooperators, and researchers are entered, quality-checked, analyzed, reported, archived, documented, cataloged, and made available for management decision-making, research, and education.

In addition to the Information Management Plan, the NCBN staff is developing specification and guidance documents to share with park, network, regional, and national staff (http://www1.nature.nps.gov/im/units/ncbn/d_guidelines.htm). These guidelines describe methods for managing natural resource information from hard copy reports to digital photos. The Network is also developing Standard Operating Procedures (SOPs) that describe in detail how to create FGDC compliant metadata and to conduct quality control procedures on data collected for Network projects. These SOPs will be included in each of the Network monitoring protocols.

For the NCBN Information Management Plan to succeed, it must:

- provide up-to-date technical guidance for the preparation and management of data (guidance, specification, and Standard Operating Procedure documents)
- maintain efficient standards for data processing, from acquisition to distribution

The resulting production of high quality information products will fulfill a wide variety of user needs.

Roles and Responsibilities

To meet the new data management goals and standards developed by the National Park Service and its constituents, Network staff must understand how data and information flow, and what their roles and responsibilities are in this process. Thus, everyone within the Network will have stewardship responsibilities in the production, analysis, management, and/or end use of data produced by the NCBN Inventory and Monitoring Program.

Network personnel will be responsible for four main categories of data stewardship:

1. production
2. analysis
3. management
4. end use

Each of these broad categories has principle or 'must-do' responsibilities as well as many potential ancillary tasks. As coordinator of these tasks, the fundamental role of the Network data manager is to understand and determine program and project requirements, to create and maintain data management infrastructure and standards, and to communicate and work with all responsible individuals.

NCBN Project Workflow

The Network handles two main types of projects:

- short-term projects (which can include individual park research projects, inventories, or pilot work as preparation for long-term monitoring)

- long-term projects (which include vital signs monitoring projects central to the I&M program and multi-year research projects and monitoring performed by other agencies and cooperators).

Long-term projects will typically require a higher level of documentation, peer review, and program support. Therefore, maintaining standardization from year-to-year will be necessary and challenging. For example, how should we compare data that's been collected at different times over an extended period of time? These and other questions will undoubtedly arise during long-term vital signs monitoring. Thus, we should know and note as much about the data when we collect and store them as we can manage.

Within the NCBN Information Management Plan, both short and long-term projects are divided into four primary stages associated with multiple information management tasks:

1. initiation and approval
2. planning/design and testing
3. implementation
4. finalization-product integration and evaluation

During the *initiation and approval stage*, the Network makes preliminary decisions regarding the scope of the project and its objectives. A scope of work may or may not be written for the project, but a proposal must be developed and funding sources, permits, and compliance must be addressed. A cooperative agreement or contract is developed and finalized. Although many of these responsibilities rest with the project leader and/or program administrators, data management staff must be involved in identifying project deliverables and assuring that each contract or agreement includes a list of these deliverables, including references to either national, regional or network information and data standards.

During the *planning/design and testing stage* of a project, an inventory study plan or a monitoring protocol is developed to detail how data will be acquired, processed, analyzed, and reported. Information management tasks associated with this stage include data design, development and maintenance of guidelines and specifications, and dissemination of this information. This stage is one of the most important as it initiates the development of high-quality data products.

Once the design, testing, and administrative tasks associated with project information management have been completed, the project *is implemented.* During this stage, the technical information management staff will determine the success of the project. Their primary tasks include acquiring, processing, and documenting the data. They initiate the development of reports, maps, and GIS themes. All raw data undergo QA/QC measures, and final manipulated products are reviewed. Although many of these tasks may be completed by Network cooperators, the information management staff must be closely involved in the training, development, and review of all draft and final project products.

After all products have been developed and reviewed extensively, *product integration and evaluation* occurs. Records are either finalized permanently for short-term projects or finalized for the project year for long-term projects. Records are finalized or closed out for the year in the Network project tracking database to reflect status and deliverables. Information management tasks include the review, dissemination, and archiving of all products.

Although Network projects vary in the final products they produce, they all follow these four basic stages. The differences between projects occur within stages and are dependent on the category and type of data being collected or compiled.

Data Acquisition and Processing

The Network acquires and manages two main categories of data:

1. **Network-based data**–those data collected by Network staff and/or cooperators working with the Network.

2. **Network-integrated data**–those data collected by other entities (e.g., parks, universities, other agencies, and other NPS programs), but recognized as important natural resource data that should be managed by the Network.

Network-based data originate within the Network or are currently being collected by NCBN staff. These include three of the twelve basic I&M Program biological inventory datasets:

- vegetation maps
- species occurrence inventories
- species distribution inventories

Along with vegetation maps and species inventories, the Network manages long-term monitoring data as part of its Vital Signs Program. NCBN is currently developing monitoring protocols for salt marsh vegetation, estuarine nekton, geomorphologic change, estuarine nutrient enrichment, landscape change, and visitor impacts.

Network-Integrated data can be divided into two additional data categories:

1. *Current or ongoing datasets* are pre-determined for acquisition by the Network and follow very specific acquisition and processing steps. These datasets can be park-based or from external NPS sources. They are protocol dependent and are acquired by the Network on a regular basis. Usually, they are used 1) for data analyses and comparison purposes with other Network-based monitoring data or 2) as baseline datasets essential for the completion of a vital sign monitoring protocol.

2. *Legacy datasets* consist of data found and compiled through the data mining process. These include vertebrate and vascular plant species data, other important natural resource inventory data, specimen or voucher data, bibliographic data, and existing monitoring datasets.

Network-based data and Network-integrated data follow slightly different acquisition and processing steps. These are described in detail in Chapter 5 of the NCBN Information Management Plan. Field data (Network-based data), data acquired from external sources, and legacy data (Network-integrated data) go through a variety of steps to reach their final archiving stage. Although some of the steps differ from one data type to another, such as the acquisition and dissemination steps, there are four main steps that all NCBN data undergo:

1. quality assurance/quality control
2. documentation
3. transcription to master databases
4. archiving

Data and other information are stored, maintained, and disseminated through Network and nationally based database management systems. (Details are available in Chapter 5 of the NCBN Information Management Plan.) NCBN vital signs data are stored in the NCBN monitoring database template. Network water quality data are housed in the national water quality database STORET. Species data are managed in the NPS NPSpecies database, and bibliographic data are compiled by the Network in the NPS NatureBib database.

Figure 6.1. Northeast Coastal and Barrier Network natural resource database template user interface example.

Quality Assurance, Quality Control

When developing a long term ecological monitoring program, it is imperative that information and data developed as part of the program be of high quality and adequate for its intended use (US EPA 2001).

To assure quality products, a plan for quality assurance as well as methods for quality control must be developed at all levels of the I&M program. Network staff and cooperators conducting ecological monitoring must be aware of the need for, and the mechanisms to achieve, excellence at all levels of product development. Thus, NCBN is developing a quality management system that will include the organizational structure, responsibilities, procedures, processes, and resources for implementing QA/QC in every facet of its ecological monitoring program.

NCBN will establish guidelines for the identification and reduction of errors at all stages in the data lifecycle, including project planning, data collection, data entry, verification and validation, processing, and archiving.

This approach requires that the Network:

- implement a quality assurance plan that includes the identification of roles and responsibilities of Network, park, and cooperative staff for maintaining quality standards at all levels of the program–from field and laboratory data collection to overall data management procedures
- ensure that the process of achieving quality is both documented and maintained through routine review by Network staff
- develop protocols and SOPs to ensure data quality
- evaluate the quality of all data and information based on NPS standards before data are distributed
- perform periodic data audits and quality control checks to monitor and improve the Network's data quality program.

Much QA/QC work involves defining and enforcing standards for electronic formats, locally defined codes, measurement units, and metadata. This process begins with data design and continues through acquisition, entry, metadata development, and archiving. The progression from raw data to verified data to validated data implies increasing confidence in the quality of the data through time. Documentation of the dataset's quality review process will be added to the project metadata.

Data Documentation

Another critical aspect of quality assurance and control is data documentation, which helps ensure that datasets are useable for their intended purposes well into the future. Data documentation includes the creation of metadata to describe how, when, and by whom a particular dataset was collected, and how the data are formatted. This information helps us create and maintain a framework for cataloging datasets, which in turn makes data more readily available to a broad range of users.

A significant amount of guidance has become available on proper data documentation (see NCBN Information Plan Appendices). As mandated by the National Park Service, all NCBN metadata associated with geospatial data will conform to Federal Geographic Data Committee (FGDC) standards. A variety of software tools are available for creating and maintaining FGDC compliant metadata.

For biological datasets, NCBN has adopted the Biological Data Profile Metadata Standards developed by the National Biological Information Infrastructure (NBII). All Network-based datasets will be accompanied by the Biological Data Profile when distributed. Northeast Region cooperators have developed helpful guidelines on tools used for creating Biological Data Profile metadata.

NCBN data management staff will provide training and support to project leaders to facilitate metadata development. Upon completion, metadata will be posted and made available and searchable in conjunction with related data and reports via the NCBN website and the national NR-GIS Metadata and Data Store.

Data Distribution

Access to NCBN data products will be facilitated via a variety of information systems that allow users to browse, search, and acquire Network data and supporting documents. These systems include the NCBN website with links to applications accessible from the internet (NatureBib, NPSpecies, NR-GIS Data Store, etc.). Table 6.1 provides a list of repositories and types of data that will or can be maintained.

Since Network data will reside in the repositories listed above, they will be "automatically searchable" via the integrated metadata and image management system and search gateway called *NPS Focus*. This system is being built with Blue Angel Enterprise software for metadata management and the LizardTech Express Server for image management. Currently, ten NPS and two non-NPS databases have been integrated into the NPS Focus prototype in either full or test bed form for one stop searching. NPS Focus has been released as an Intranet version only, but the release of a public version is projected in the near future.

Archiving

Archiving of data is critical to the long-term success of the Inventory and Monitoring Program. Therefore, the Network will provide a framework for long-term maintenance and management of digital and analog information. Technological obsolescence is a significant cause of information loss, and data can quickly become inaccessible to users if they are stored in out-of-date software programs or on outmoded media. Effective maintenance of digital files depends on the proper management of a continuously changing infrastructure of hardware, software, file formats, and storage media. Major changes in hardware can be expected to occur every 1-2 years and in software every 1-5 years (Vogt-O'Connor 2000).

Table 6.1. Information management systems that facilitate dissemination of NCBN information.

Web Application	Data types available at site	Web Address
NPSpecies	Data on park biodiversity (species information)	http://science.nature.nps.gov/ im/apps/npspp/ index.htm
NatureBib	Scientific citations related to park resources	http://www.nature.nps.gov/ nrbib/index.htm
NR-GIS Metadata and Data Store	Metadata, spatial and non-spatial data products	http://science.nature.nps.gov/nrdata
Biodiversity Data Store	The raw or manipulated data and products associated with I&M data that have been entered into NPSpecies.	http://science.nature.nps.gov/ im/inventory/ biology/index.htm
NCBN Website	Reports and metadata for all Network projects	http://www1.nature.nps.gov/ im/units/ncbn/ index.htm

As software and hardware evolve, datasets must be consistently migrated to new platforms. Or, alternatively, they must be saved in formats that are independent of specific platforms or software (e.g., ASCII delimited files). Thus, NCBN archiving procedures include saving datasets in both their native format (typically MS-Access or Excel spreadsheet format) and as sets of ASCII text files. As a platform and software independent format, ASCII text files ensure future usability of the data in a wide range of applications and platforms. In addition, datasets will periodically be converted to upgraded versions of their native formats.

Chapter 10 of the NCBN Information Management Plan describes procedures for maintaining and managing digital data, documents, and objects that result from Network projects and activities. These procedures will help ensure the continued availability of crucial project information and permit a broad range of users to obtain, share, and properly interpret that information. Figure 6.2 illustrates the data flow process from data acquistion to distribution.

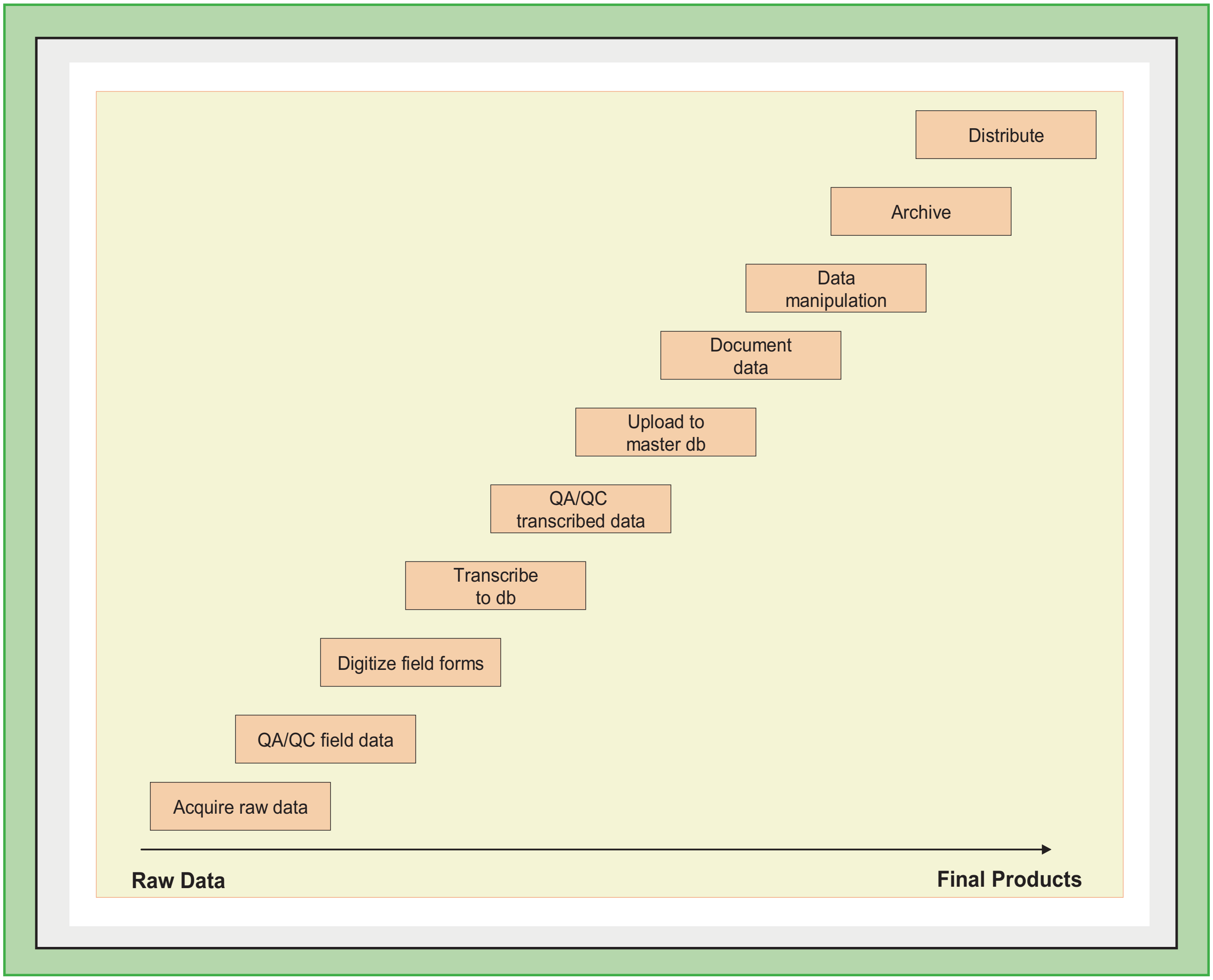

Figure 6.2. Northeast Coastal and Barrier Network data flow conceptual model.

Chapter 7 Data Analysis and Reporting

The broad-based, scientifically sound information obtained through natural resource monitoring has multiple applications in management decision-making, research, education, and promoting public understanding of park resources. The primary audience for information gathered as part of the Northeast Coastal and Barrier Network Vital Signs Monitoring Program will be park managers. However, other key audiences will include park planners, interpreters, researchers and other scientific collaborators, the general public, Congress, and the President's Office of Management and Budget (OMB). To be most effective, monitoring data must be analyzed, interpreted, and provided at regular intervals to each of these key audiences in a format they can use and understand. This means that there must be several different scales of formatting, packaging and distributing this information to this wide variety of audiences.

The scientific data needed to better understand how park systems work and to better manage the parks will come from many sources. In addition to new field data collected through the I&M Program, data to help us determine the status and trend in the condition of park resources will come from other park projects and programs, other agencies, and from the general scientific community (Figure 7.1). To the extent that staffing and funding is available, the Network

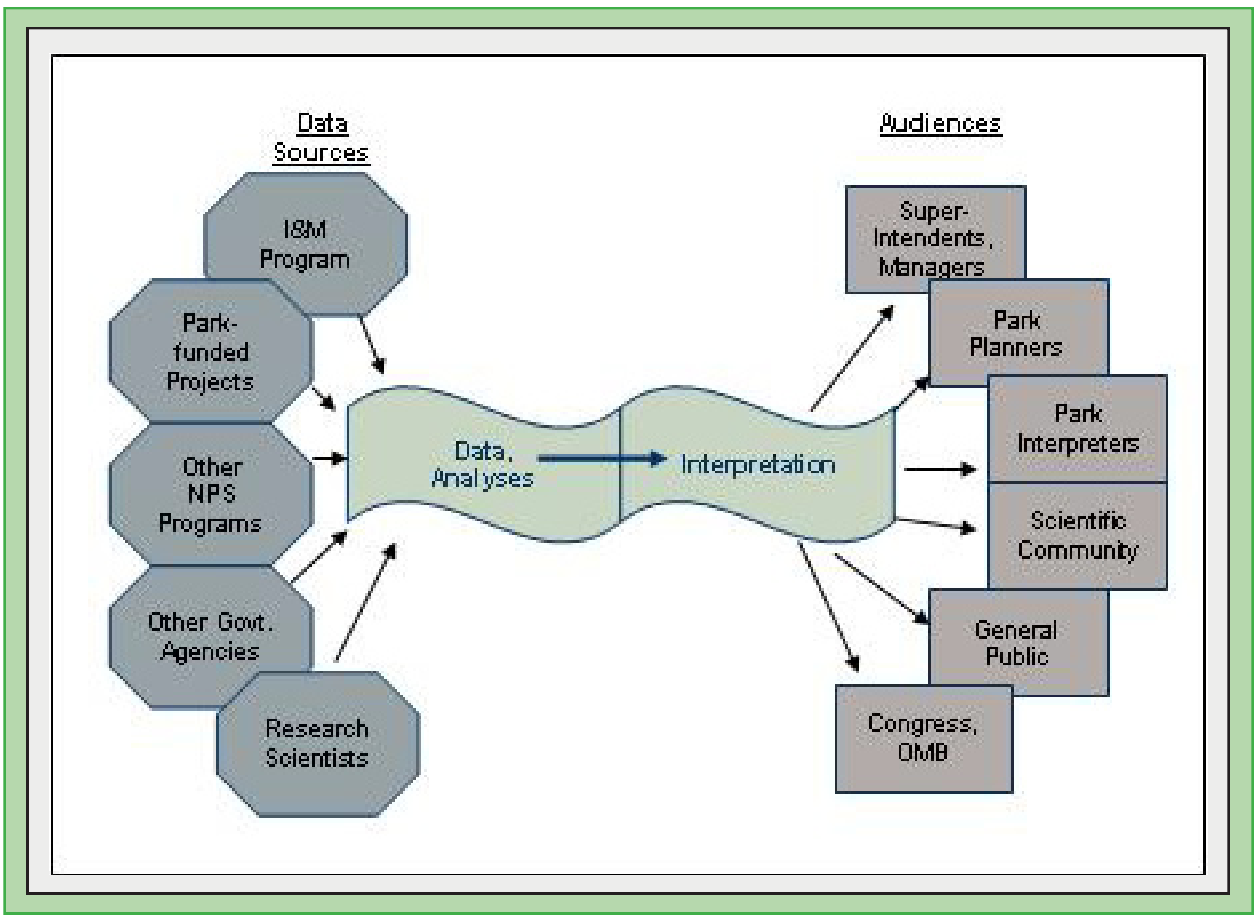

Figure 7.1. Potential data sources to be used by the Northeast Coastal and Barrier Network to help determine the status and trends in the condition of park resources and the principle audiences that the Network will be interpreting the data and information for.

Gateway National Recreation Area, Staten Island, New York Unit.

monitoring program will collaborate and coordinate with these other data collection and analysis efforts, and will promote the integration and synthesis of data across projects, programs, and disciplines.

Information is the common currency among the many different activities and people involved in the stewardship of a park's natural resources. The projects and people involved with activities such as park planning, inventories, short- and long-term monitoring, research studies, restoration activities, control of invasive species, T&E species management, fire management, trail and road maintenance, law enforcement, and interpretation all require and/or provide natural resource information to others. As part of the Service's effort to "improve park management through greater reliance on scientific knowledge", a primary role of the Inventory and Monitoring Program is to develop, organize, and make available natural resource data and to contribute to the Service's institutional knowledge by facilitating the transformation of data into information through analysis, synthesis, and modeling.

This chapter presents an overview of how the Network proposes to analyze, synthesize, and disseminate monitoring results to its key audiences.

Analysis of Monitoring Data

Appropriate analysis of monitoring data is directly linked to the monitoring and sampling objectives, as well as the spatial and temporal aspects of the sampling design used. Analyses need to be considered when developing the sampling design, rather than after data are collected. Each monitoring protocol (see Chapter 5) will contain detailed information on analytical tools and approaches for data analysis and interpretation, including the rationale for a particular approach, advantages and limitations of each procedure, and standard operating procedures (SOPs) for each prescribed analysis.

Table 7.1 summarizes four general categories of analysis for NCBN vital signs, and the lead responsible for each. The lead analyst will ensure that data are analyzed and interpreted within the guidelines of the protocol and program, but they may not actually perform the analyses or interpret the results in some cases.

Communications and Reporting

The various approaches and products the Network plans to use to disseminate the results of the monitoring program and to make the data and information more available and useful to key audiences are organized into the following seven categories and described in the following sections:

1. Annual Reports for Specific Protocols and Projects
2. Annual Briefings to Park Managers
3. Analysis and Synthesis Reports
4. Protocol and Program Reviews
5. Scientific Journal Articles and Book Chapters, and Presentations at Scientific Meetings
6. Internet and Intranet Websites
7. Interpretation and Outreach

Annual Reports for Specific Protocols and Projects

The primary purposes of annual reports for specific protocols and projects are to:

- summarize and archive annual data and document monitoring activities for the year;
- describe current condition of the resource;

Table 7.1. General categories of analyses used for Northeast Coastal and Barrier Network vital

Level of Analysis	Description	Lead Analyst
Data Summarization/ Characterization	Summarization is the calculation of basic statistics of interest from the monitoring data. It will encompass measured and derived variables specified in all monitoring protocols. Data summarization and characterization will form the basis of more comprehensive analyses, and for communicating results in both graphical and tabular formats.	The program lead for each monitoring protocol, working with the data management staff, will produce routine data summaries (See NCBN Data Management Plan Chapt 8). Parameters and procedures are specified in each protocol data analysis SOP.
Status Determination	Analysis and interpretation of the ecological status (point in time) of a vital sign to address the following types of questions: •How do observed values for a vital sign compare with historical levels? •Do observed values exceed a regulatory standard, known or hypothesized ecological threshold? What is the level of confidence that the exceedance has actually occurred? •What is the spatial distribution (within park, network, ecoregion) of observed values for a given point in time? Do these patterns suggest directional relationships with other ecological factors? Status determination will involve both expert interpretation of the basic statistics and statistical analysis to address these monitoring questions. Assumptions about the target population and the level of confidence in the estimates will be ascertained during the analysis.	The program lead for each monitoring protocol is the lead analyst for status determination, although the Network Coordinator, cooperators, partners, interns or other network staff may conduct analyses and assist with interpreting results. Consultation with regulatory and subject matter experts will support status determination.
Trends Evaluation	Evaluations of trends in vital signs will address: •Is there directional change in a vital sign over the period of measurement? •What is the rate of change (sudden vs. gradual), and how does this pattern compare with trends over broader spatial scales and known ecological relationships? •What is the level of confidence that an actual change (or lack thereof) has occurred? Analysis of trends will employ parametric, nonparametric, or mixed models based on assumptions that can or cannot be reasonably made about the target population. Where appropriate, exogenous variables (natural, random phenomena that may influence the response variable) will be accounted for in the analysis.	The program lead for each monitoring protocol is the lead analyst for trend evaluation, although the Network Coordinator, cooperators, partners, interns or other network staff may conduct analyses and assist with interpreting results. Comparison with relevant long-term experimental results will aid interpretation.
Synthesis and Modeling	Examination of patterns across vital signs and ecological factors to gain broad insights on ecosystem processes and integrity. Analyses may include: •Qualitative and quantitative comparisons of vital signs with known or hypothesized relationships. •Data exploration and confirmation (e.g., correlation, ordination, classification, multiple regression, structural equation modeling). •Development of predictive models. Synthetic analysis has great potential to explain ecological relationships in the nonexperimental context of vital signs monitoring and will require close interaction with academic and agency researchers.	The Network Coordinator is the lead analyst for data synthesis and modeling, in collaboration with each project leader. Cooperators, partners, interns or other network staff may conduct analyses and assist with interpreting results. Integration with researchers and experimental results is critical.

Diamondback Terrapin (*Malaclemys terrapin*) hatchling found at Gateway National Recreation Area.

- document changes in monitoring protocols; and,
- increase communication within the park and network.

The primary audiences for these reports are park superintendents and resource managers, network staff, park-based scientists, and collaborating scientists. Most annual reports will receive peer review at the network level, although a few may require review by subject matter experts with universities or other agencies. Some monitoring protocols involve data collection each year, and those protocols will generate an annual report each year. However, some sampling regimes do not involve sampling every year - those projects will produce "annual" reports only when there are significant monitoring activities to document. Wherever possible, annual reports will be based on automated data summarization routines built into the MS Access database for each protocol. The automation of data summaries and annual reports will facilitate the Network's ability to manage multiple projects and to produce reports with consistent content from year to year at timely intervals. For analyses beyond simple data summaries, data will first be exported to external statistical software.

Annual Briefings to Park Managers

Each year, in an effort to increase the availability and usefulness of monitoring results for park managers, the Network Coordinator will take the lead in organizing a 1-day "Science briefing for park managers" (possibly in conjunction with a Board of Director's meeting) in which network staff, park scientists, USGS scientists, collaborators from academia, and others involved in monitoring the parks' natural resources will provide managers with a briefing on the highlights and potential management action items for each particular protocol or discipline. Unlike the typical science presentation that is intended for the scientific community, someone representing each protocol, program, or project will be asked to identify key findings or "highlights" from the past year's work, and to identify potential management action items. The scientists will be encouraged to prepare a 1- or 2-page "briefing statement" that summarizes the key findings and recommendations for their protocol or project; these written briefing statements will then be compiled into an annual 'Status and Trends Report' for the Network. In the process of briefing the managers, the various scientists involved with the monitoring program will learn about other protocols and projects. The briefings will facilitate better coordination and communication and will promote integration and synthesis across disciplines. Managers and the Network Coordinator will be encouraged to review the briefing statements and formulate management questions for scientists.

In addition to the annual briefings, the Network produces an Annual Administrative Report and Work Plan (AARWP). This report can be used by managers to report to GPRA. It is an excellent communication tool used to keep the Network Board of Directors up to date on accomplishments and projected work for the following fiscal year. The AARWP written by all 32 networks, is also used to present findings and data to Congress and the Office of Management and Budget. Both inventory and monitoring accomplishments are provided in these reports.

Analysis and Synthesis Reports and Review

The role of analysis and synthesis reports is to:

- determine patterns/trends in condition of resources being monitored;
- discover new characteristics of resources and correlations among resources being monitored;
- analyze data to determine amount of change that can be detected by this type and level of

Table 7.2. Northeast Coastal and Barrier Network Vital Signs protocols and associated analyses.

Protocols	Analysis and Report Responsibilities	Analyses Performed
Ocean Shoreline Position	Geomorphological Monitoring Program Lead (currently Network staff)	Summary statistics, others to be determined
Coastal Topography	Geomorphological Monitoring Program Lead (currently Network staff)	Summary statistics, others to be determined
Salt Marsh Nekton	Salt Marsh Monitoring Program Lead (Network staff)	**Summary statistics** include: species composition (species lists); average total nekton density; and total number of individuals collected. **Trend analyses** include: Analysis of Variance to determine if nekton densities are changing over time; distribution tests, such as the Kolmogorov-Smirnov test, to determine if size-frequency distributions of a species are changing over time; changes in community structure (species composition and abundance) can be assessed by non-parametric permutation procedures to detect differences in community structure.
Salt Marsh Vegetation	Salt Marsh Monitoring Program Lead (Network staff)	**Summary statistics** include: species composition; and percent cover for all cover types. **Trend analyses** include: community analysis to determine trend in vegetation communities; and non-parametric tests to detect differences in community structure (i.e., species composition and abundance).
Salt Marsh Elevation	Salt Marsh Monitoring Program Lead (Network staff)	Summary statistics, others to be determined
Estuarine Eutrophication	Estuarine Eutrophication Program Lead (Network staff)	Summary statistics, others to be determined
Estuarine Nitrogen Loading	Not yet determined	Summary statistics, others to be determined
Visitor Impacts	Not yet determined	Summary statistics, others to be determined
Visitor Use	Not yet determined	Summary statistics, others to be determined
Landscape Change	Not yet determined	Summary statistics, others to be determined

sampling;

- provide context: interpret data for the park within a multi-park, regional or national context;
- recommend changes to management of resources (feedback for adaptive management).

The primary audiences for these reports are park superintendents and other resource managers, network staff, park-based scientists, and collaborating scientists. These reports will receive external peer review by at least 3 subject-matter experts, including a statistician. Analysis and synthesis reports can provide critical insights into resource status and trends, which can then be used to inform resource management efforts and regional resource analyses. This type of analysis, more in depth than that of the annual report, requires several seasons of sampling data. Therefore, these reports are usually written at intervals of every three to five years for resources sampled annually, unless there is a pressing need for the information to address a particular issue. For resources sampled less frequently, or which have a particularly low rate of change, intervals between reports may be longer.

Table 7.2 provides a preliminary list of analyses, both annual and trend, that will be conducted under each protocol. As depicted in this table, most of the NCBN protocols are still being revised and the analyses sections not completed. The estuarine eutrophication protocol is currently being peer reviewed, and database development and automated analyses are in development. As these are completed Table 7.2 will be completed.

Examination of vital signs and ecological systems is an important analytical tool to better interpret changes to park resources. This will be accomplished with a network synthesis report produced at no more than 10-year intervals. The Network Coordinator and each program leader will be responsible for working together and developing the synthesis report

Program Review

The Network Coordinator will initiate the Network Monitoring Program review (Table 7.3). The purpose of these reviews is to have the program evaluated by highly qualified professionals. Features include:

- Network staff and collaborators provide a summary of the program and activity to date including a summary of results and outcomes of any protocol reviews.
- Scientific review panel obtains input from Board of Directors, network staff, park scientists, and others. Panel holds a workshop to discuss the program and whether it is meeting its goals and expectations. Review Panel makes recommendations for improving the effectiveness and value of the monitoring program.
- Network Coordinator develops a strategy with the NCBN Technical Steering Committee and Board of Directors as to which of the review panel's recommendations to implement, how, and when.

Table 7.3. Northeast Coastal and Barrier Network Vital Signs Protocol Trend Report and Review Schedule. (Note – Each protocol will also produce Annual Project Reports.)

Protocol	Year and Report T = Trend Report R = Program and Protocol Review									
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ocean Shoreline Position					R	T				
Coastal Topography					R	T				
Salt Marsh Nekton	T				R		T			
Salt Marsh Vegetation	T				R		T			
Salt Marsh Elevation	T				R		T			
Estuarine Eutrophication		T			R			T		
Estuarine Nitrogen Inputs		T			R			T		
Visitor Use			T		R				T	
Visitor Impacts			T		R				T	
Landscape Change				T	R					T

Topics to be addressed during the program review include program efficacy, accountability, scientific rigor, contribution to adaptive park management and larger scientific endeavors, outreach, partnerships, data management procedures, and products. These reviews cover monitoring results over a longer period of time, as well as program structure and function to determine whether the program is achieving its objectives, and also whether the list of objectives is still relevant, realistic, and sufficient.

As part of the quality assurance process for the Network's program, review reports will assess the quality and efficiency of Network operations, including a review of protocol designs, products and reports for each of the protocols. The NCBN Program and Protocol Review Report will be produced every 6 years as part of a rotating schedule along with the monitoring protocol trend reports (Table 7.3). This report will be produced after each full cycle of trend reports in order to allow for a better assessment of the status of the Network and each project.

Scientific Journal Articles, Book Chapters, and Presentations at Scientific Meetings

The publication of scientific journal articles and book chapters is done primarily to communicate advances in knowledge, and is an important and widely-acknowledged means of quality assurance and quality control. Putting a program's methods, analyses, and conclusions under the scrutiny of a scientific journal's peer-review process is basic to science and one of the best ways to ensure scientific rigor. Network staff, park scientists, and collaborators will also periodically present their findings at professional symposia, conferences, and workshops as a means of communicating the latest findings with peers, identifying emerging issues, and generating new ideas.

All journal articles, book chapters, and other written reports will be listed in the Network's Annual Administrative Report and Work Plan that is provided to network staff, Technical Committee, Board of Directors, and regional and national offices each year. Additionally, all scientific journal articles, book chapters, and written reports will be entered into the NatureBib bibliographic database maintained by the Network.

Internet and Intranet Websites

Internet and (restricted) intranet websites are a key tool for promoting communication, coordination, and collaboration among the many people, programs, and agencies involved in the Network monitoring program. All written products of the monitoring effort, unless they contain sensitive or commercially valuable information that needs to be restricted, will be posted to the main network website.

Documents to be posted to the Network website include this monitoring plan, all protocols, annual reports, analysis and synthesis reports, and other materials of interest to staff at the park, network, regional, and national levels, as well of being of interest to our collaborators.

In addition, to promote communication and coordination within the Network, a password-protected site is maintained where draft products, works in progress, and anything that needs to have restricted access is shared within the program.

Interpretation and Outreach

The National Park Advisory Board, in their July 2001 report "Rethinking the National Parks for the 21st Century", wrote that "A sophisticated knowledge of resources and their condition is essential. The Service must gain this knowledge through extensive collaboration with other agencies and academia, and its findings must be communicated to the public. For it is the broader public that will decide the fate of these resources." The Network will make a concerted effort, working with park interpreters and others, to ensure that the results of natural resource monitoring are made available to the interested public. In addition to providing scientific reports and briefings to managers for their protocols, each scientist involved with the Network will be asked to contribute story ideas, photographs, and other materials to interpreters for use in newsletters, interpretive talks and exhibits, and other media for informing and entertaining the public. Park interpreters will be invited to participate in monitoring field efforts to increase communication and promote integration between the programs.

Interpretation and outreach is a perfect place for the NCBN Vital Signs Monitoring program to team up with the two Learning Centers in the Network, one at Cape Cod National Seashore and one at Gateway National Recreation Area. These learning centers promote research in parks, as well as act as bridges between scientists and the public.

Chapter 8 Program Administration

This chapter includes information on the administrative structure of the Northeast Coastal and Barrier Network, including staffing, operations, safety, integration with other programs, and program review procedures.

Administration

Governing Structure

The governing structure of the Network includes a Board of Directors and a Technical Steering Committee. Program administration is governed by the Service-wide I&M program, which provides monitoring program goals and overall planning guidance.

Network Charter

The Network charter (NCBN 2001e) describes the basic practices used to plan, organize, manage, evaluate and modify the NCBN vital signs monitoring program. The charter also explains the roles and functions of the Board of Directors and Technical Steering Committee.

Board of Directors

Overall direction for the NCBN is provided by a Board of Directors (BOD) which consists of: NCBN Park Superintendents, Northeast Region's two Chief Scientists, the Northeast Regional I&M Coordinator, and the NCBN Coordinator (see Table 8.1). All members of the board have equal status, and decisions are made by consensus. Once the Board reaches a decision the Superintendent of Cape Cod NS has been authorized to sign documents as the Board's representative. The Board of Directors meets at least once a year (usually by teleconference) to approve the annual administrative report and work plan; other meetings are arranged as needed. Routine decisions requiring input from the Board are discussed and voted on via electronic mail. The major responsibilities of the Board of Directors are:

- To require accountability and effectiveness for the NCBN I&M Program by reviewing progress, quality control, and spending of network funds.
- To provide guidance to the Network Coordinator,

Table 8.1. Northeast Coastal and Barrier Network Board of Directors (Sept. 2005).

Name	Position
Barry Sullivan	General Superintendent Gateway NRA
Beth Johnson	Northeast Regional Inventory & Monitoring Coordinator
Bryan Milstead	Northeast Coastal and Barrier Network Coordinator
Dan Smith	Superintendent Colonial NHP
George Price	Superintendent Cape Cod NS
Greg Marshall	Superintendent (Acting) Sagamore Hill NHS
John Karish	Northeast Region Chief Scientist
Mary Foley	Northeast Region Chief Scientist
Mike Hill	Superintendent Assateague Island NS
Mike Reynolds	Superintendent Fire Island NS
Vidal Martinez	Superintendent Thomas Stone NHS & G. Washington Birthplace NM

Network Data Manager, Technical Steering Committee and natural resource staff of the Network's parks in the purpose, design and implementation of vital signs monitoring and other management activities related to the Natural Resource Challenge.

- To decide on strategies and procedures for leveraging network funds and personnel to best accomplish inventory and monitoring needs of Network parks.
- To consult on hiring Network personnel using funding provided to the Network, including base funds and other sources.
- To seek additional financial support to leverage the Servicewide funds.
- To solicit professional guidance from and partnerships with other governmental agencies, organizations and individuals.
- To serve as advocates for the Natural Resource Challenge and promote understanding of the importance of the Inventory and Monitoring program among park staff, visitors and decision makers.

Technical Steering Committee

The Technical Steering Committee provides technical assistance and advice to the Board of Directors and network staff in developing a long-term monitoring strategy. This committee is composed of natural resource managers from network parks, the Northeast Region's two Chief Scientists, the Northeast Regional Inventory and Monitoring Coordinator, the NCBN Coordinator and Data Manager, the North Atlantic CESU research coordinator, and USGS scientists who work in the parks and are familiar with park issues (see Table 8.2). The Committee meets at least once each year for program review; individual members also give advice to the Network on matters relating to their areas of expertise when the need arises. The Steering Committee is responsible for:

- Compiling and summarizing existing information about park resources.
- Developing materials for and summarizing the findings and recommendations of scoping workshops held to develop a Network monitoring strategy.
- Participating in the identification of monitoring objectives and development of the Network Strategic Plan.
- Assisting in the selection of vital signs.
- Assisiting in peer review of protocols.
- Evaluating initial sampling designs, methods

Table 8.2. Northeast Coastal and Barrier Network Technical Steering Committee (2005).

Name	Location	Position
Beth Johnson	NPS NER	NE Region I&M Coordinator
Bryan Milstead	NPS NCBN	NCBN Coordinator
Sara Stevens	NPS NCBN	NCBN Data Manager
Carl Zimmerman	NPS ASIS	Chief of Natural Resources
Charles Rafkind	NPS COLO	Natural Resource Manager
Charles Roman	NPS NER	North Atlantic CESU Research Coordinator
Hilary Neckles	USGS PWRC	Research Scientist
Howard Ginsberg	USGS PWRC	Ecologist
John Karish	NPS NER	Northeast Region Chief Scientist
John Sauer	USGS PWRC	Wildlife Biologist
Mary Foley	NPS NER	Northeast Region Chief Scientist
Nancy Finley	NPS CACO	Chief of Natural Resources
Michael Bilecki	NPS FIIS	Chief of Natural Resources
Allan O'Connell	USGS PWRC	Wildlife Biologist

(Note: USGS PWRC=United States Geological Survey, Patuxent Wildlife Research Center).

Coquina clams (*Donax variabilis*) found in the surf at Assateague Island National Seashore, MD/VA.

and protocols, analysis and synthesis reports.

- Reviewing annual data reports and interpretation as well as participating in the preparation of the Annual Work Plan and Annual Report.
- Developing materials for and facilitating the Program Review.
- Designing Position Descriptions and hiring of Network personnel.

Administrative Support

The Network receives the majority of its administrative support from the Northeast Region (NER) offices in Boston, MA and Philadelphia, PA. This support includes personnel functions such as: 1) position classification, recruitment, human resources and development; 2) budget and contracting obligations through cooperative agreements, interagency agreements and contracts; and 3) purchasing, property management and inventory. The Network also receives administrative assistance from the two Chief Scientists of the region and their staff. The Program Analyst for the Boston Office Chief Scientist handles time and attendance (payroll input), requests for personnel actions, budget tracking and expenditure transfers.

Supervision

The Network Coordinator is supervised by the Northeast Region Inventory and Monitoring Coordinator. The Network Coordinator supervises all other, both permanent and temporary Network staff.

Office Location

The Northeast Coastal and Barrier Network is located at the University of Rhode Island and receives office space and logistical support from the Natural Resources Science Department through a cooperative agreement. Additional network personnel are currently located at Assateague Island National Seashore and the Boston Office of the Northeast Region. As the program expands existing duty stations may change, and it may be necessary to place more staff in parks.

Staffing

Core Network Staff

Four staff members make up the "core staff" of the NCBN, including the Network Coordinator, Data Manager, GIS Specialist, and Biologist (see Table 8.3 for a description of the responsibilities for each position). Currently the GIS specialist is duty stationed at Assateague Island NS and the remaining three are located at the University of Rhode Island. The Core Staff hold responsibility for vital signs planning and, together with term and seasonal employees, affiliate park staff, and cooperators will implement the program.

Flexible Staffing Plan

Staff needs during implementation will be driven by the overall monitoring design and resultant technical needs. The roles, responsibilities and duty stations of staff, particularly field sampling crews, will depend on the requirements described in the monitoring protocols that are under development (see Chapter 5). For this reason, the Network requires a flexible pool of capable individuals to initially implement

Table 8.3. Core Network staff roles and responsibilities.

	Role & Responsibility
Network Coordinator	The Coordinator is responsible for the overall management and supervision of the program. The Coordinator works closely with the Board of Directors, the Technical Steering Committee and the Cape Cod Prototype Coordinator to develop a scientifically credible inventory and monitoring program that addresses the needs of the Network Parks. This position coordinates data acquisition, analysis and reporting for specific projects and insures that all results are communicated to park managers and staff, and interested public in useful formats. The Coordinator also develops partnerships with similar programs on adjacent lands and appropriate regional and national monitoring programs.
Biologist	The Biologist is the primary advisor to the Network Coordinator and is responsible for the scientific and statistical components of the program. The Biologist participates in the design, development, and testing of long-term monitoring protocols, as well as directing data collection procedures and conducting analysis of data for specific projects. The Biologist also reports the significance of findings to park managers and interested public, and coordinates the Network's inventory program.
Data Manager	The Data Manager is responsible for the information and data stewardship of the program. The Data Manager performs the following duties: design, development and management of complex database systems for the long-term maintenance, analysis and dissemination of natural resource data; and management of the GIS and database management software, GPS data dictionaries, and spatial data inventories. The Data Manager insures that all products have appropriate metadata and are archived following NPS accepted standards.
GIS Specialist	The GIS Specialist coordinates the Network's shoreline change and coastal topography monitoring projects and assists the Data Manager with: design, development and management of complex database systems for the long-term maintenance, analysis and dissemination of spatial and remote sensing datasets; and management of the GIS software, GPS data dictionaries and spatial data inventories. The GIS specialist insures that all spatial data have appropriate metadata and are archived following NPS accepted standards. This position is also responsible for maintenance and support for the Network's GPS equipment.

monitoring protocols, conduct pilot studies, perform data management projects and assist in the analysis and reporting of monitoring data. Options include: hiring NPS personnel; hiring CESU cooperators (normally through universities); creating interagency agreements; and hiring government contractors.

At the same time, experience demonstrates that having a professional NPS staff bridge the planning and implementation process facilitates working with network parks and will ensure stronger, more relevant products emerging from these cooperative relationships. To increase overall effectiveness, the Network may hire staff members who are duty stationed in network parks or rely on existing park natural resource staff for part of the monitoring. A core staff, along with affiliated park staff can provide the continuity among program staff and a programmatic history essential to the success of a long-term monitoring program.

Decisions to identify affiliated park positions such as project leaders and/or crew members will only be exercised when the following requirements can be met: 1) capable staff already exist at the park and are available to conduct monitoring; 2) the park can provide work space; and 3) there are mechanisms in place to assure the work is completed following the guidelines in the monitoring protocol and the schedule established in the annual work plan. One example where NCBN is working with affiliated park staff is in the implementation of the ocean shoreline position monitoring protocol.

Critical results

Once staffing needs have been filled and individuals are assigned to monitoring projects, it is important that the employee has a clear understanding of his/her roles and responsibilities. Managing individual performance and seeing that the employees carry out their assigned duties according to established protocols is the responsibility of the supervisor. Communication is especially important when a park employee is assigned to the responsibility of collecting data for the network. In these instances, it is essential that the primary supervisor interact with the network program manager to develop and evaluate employee performance, as established in the annual employee performance plan.

Operations

Safety

All federal regulations as well as all procedures from the Department of the Interior and National Park Service regarding safety and training will be adhered to during the implementation of monitoring protocols. In addition, each vital signs monitoring protocol will outline the procedures for the safe use of any necessary equipment. The occupational safety and health standards for all federal employees are located in Title 29 of the Occupational Safety and Health Administration regulations (US Department of Labor 1999) The Department of the Interior's Safety and Occupational Health Manual DM 485, provides more detailed departmental standards, along with the department's SafetyNet website is a useful location for health and safety policy and information. The NPS safety information portal is called RiskNet and provides many valuable links such as to the NPS Safety Management Information System, the NPS Incident Management Analysis & Reporting Program, and Directors Orders regarding Workers Compensation, Occupational Safety and Health, and Public Safety.

Probably the most important safety standards for the implementation of monitoring protocols are those relating to motor vehicle, aircraft, and boat use. All staff or contractors will meet the minimum requirements for operating motor vehicles and receive training as necessary, as detailed in the Department of the Interior (DOI) motor vehicle safety standards in the Departmental Manual (US Department of Labor 1999).

Aircraft will likely be utilized for data collection through the Coastal Topography protocol and possibly for the data collection through the Landscape Change protocol. In October 2001, the Office of Aircraft Services (OAS) was realigned under the Department of the Interior, National Business Center as the Aviation Management Directorate (AM). All personnel involved with aviation use in support of Network projects will receive proper training before participation. Aircraft operating will be conducted under cooperative agreement with OAS approved vendors.

Similarly, all personnel operating boats in association with the Estuarine Eutrophication, Salt Marsh, or other projects will follow the standards and requirements of DOI and NPS. Minimum requirements for the safe operation of DOI watercraft and for the certification of watercraft operators are found in Department Manual, Part 485, Safety and Occupational Health Program, Chapter 22. Under these requirements, all DOI staff that operate watercraft must be certified via the Motorboat Operator Certification Course, and must maintain their certification status with a refresher course. Network parks require that all contractors who operate boats in the parks also meet these standards.

Cape Cod National Seashore salt marsh in fall.

Integration

Integration with Park Operations

An active partnership between the Network, park staff and participating cooperators is essential for the vital signs monitoring program. The Network and parks have worked together at various levels throughout the planning and development of monitoring protocols, and will continue to do so as projects are implemented. On an operational level implementation will require coordination of and sharing of personnel and equipment. To be completely successful the Network will need to interact with all park management divisions. Strong ties to administration and resource management divisions have already been established the Network is exploring ways to involve the visitor protection, maintenance, and interpretation divisions in data collection. Perhaps the strongest link will be established through effective communication. The Network will maintain close contact with the Parks and will develop interpretative materials such as powerpoint presentations, brochures, newsletters, and posters for dissemination.

Integration with other Natural Resource Challenge Programs

When possible the Network coordinates activities with other Natural Resource Challenge programs in the region.

- The Network has a strong working relationship with the **Cape Cod National Seashore Prototype Monitoring Program** and there is considerable sharing of information, protocols, and expertise between the two programs.
- The Network works with the **North Atlantic Cooperative Ecosystems Study Unit** to develop and fund proposals to support the monitoring program.
- The four inventory and monitoring Networks in the Northeast Region, the **Northeast Coastal and Barrier Network**, the **Northeast Temperate Network**, the **Eastern Rivers and Mountains Network**, and the **Mid-Atlantic Network** frequently collaborate on projects and cooperative agreements. Three of the protocols being developed by this Network are being adapted for use in the Northeast Temperate Network as well.
- The two **Research Learning Centers** in the Network, the **Jamaica Bay Institute** (Gateway N.R.A.) and the **Atlantic Research Center** (Cape Cod N.S.) provide important logistical support for field projects and attract researchers with the potential to collaborate on projects.
- In the future, the Network will also have the opportunity to work with the **Mid-Atlantic Exotic Plan Management Team** and the **Northeast Exotic Plan Management Team** on invasive plant issues.

Key Cooperators

There are abundant opportunities for the establishment of effective collaborations in the Northeast. The Network has engaged cooperators with long standing relationships with NCBN parks and programs. The NCBN has relied heavily on University and the United States Geological Survey Scientist for assistance with the design of the monitoring program, protocol development, database management, and logistical support. The key cooperators currently assisting the Network are listed in table 8.4. All cooperative agreements are reported on in the Annual Administrative Report.

Program Review

An in-depth programmatic review will occur every six years from the time that the monitoring plan is implemented in October 2005 (see Chapter 7). The program review will provide the basis for any significant changes in program direction, and any

Table 8.4. Northeast Coastal and Barrier Network cooperative and interagency agreements associated with the Network's Vital Signs Program (2005).

Cooperator	Affiliation	Agreement	Task(s)
Dr. Peter Paton	Univ. of Rhode Island	Cooperative (CESU)	Provide office space and logistical support to the Network.
Dr. Hilary Neckles & Dr. Blaine Kopp	USGS Patuxent	Interagency	Protocol development and implementation for estuarine eutrophication vital signs.
Dr. Scott Nixon	Univ. of Rhode Island	Cooperative (CESU)	Protocol development for estuarine nitrogen inputs vital sign.
Dr. M.J. James-Pirri	Univ. of Rhode Island	Cooperative (CESU)	Protocol development and implementation for salt marsh vegetation and nekton vital signs.
Dr. Don Cahoon	USGS Patuxent	Interagency	Protocol development and implementation for salt marsh sediment elevation vital sign.
Dr. John Brock & Wayne Wright	USGS Coastal Services Center & NASA	Interagency	Lidar data collection and management. Development of Standard Operating Procedures for the analysis of Lidar data.
Dr. Norb Psuty	Rutgers University	Cooperative (CESU)	Protocol development and implementation for the shoreline change vital sign.
Dr. Christopher Monz & Dr. Yu Fai Leung	St. Lawrence University & North Carolina State University	Cooperative	Identification and prioritization of visitor use and visitor impact vital signs.
Dr. Y.Q Wang	Univ. of Rhode Island	Cooperative	Development of Standard Operating Procedures for the detection of landscape change with satellite remote sensing data.
Dr. Peter August & Chuck Labash	Univ. of Rhode Island	Cooperative (CESU)	Database development, GIS and data management support.
Dr. Hugh Devine	North Carolina State University	Cooperative	Data Management and archiving.
Gary Entsminger	Rocky Mountain Biological Lab.	Cooperative	Technical writing and database design.

recommendations will be forwarded to the National I&M office. The review will focus on all the aspects of the monitoring plan, including monitoring priorities, data management and analysis, annual budget, and staffing. Vital signs will be reviewed to make sure that they are still priorities and that annual budgets are still adequate. Staffing numbers will be reviewed to evaluate what staffing changes, if any, need to be made.

Chapter 9 Schedule

The Northeast Coastal and Barrier Network is using a phased approach in the development of ten vital signs monitoring protocols. This chapter describes the status of each protocol and the schedule for protocol completion, review and implementation.

Assateague Island National Seashore, Maryland/Virginia.

Planning and Implementation Schedule for Vital Signs Monitoring Projects

Protocol development includes refining and testing methods, pilot data collection, analyses of pilot data to determine adequate sample size, and refinement of sampling based on these analyses. Pilot data collection occurs during the field season following submission of draft protocols for review.

Not all monitoring activities will begin upon the completion of this monitoring plan. Development and testing of monitoring protocols will continue through 2007, and implementation for some protocols is not expected to occur until 2008 (Table 9.1). Some field testing of draft protocols began in selected network parks in 2005, these include: salt marsh vegetation (James-Pirri and Roman 2004a); nekton (James-Pirri and Roman 2004b); ocean shoreline position (Duffy *et al.* 2005); and estuarine eutrophication (Kopp and Neckles 2004). Full implementation of these four protocols will begin in 2006 once peer review and revisions are complete. Draft versions of these protocols are available on the Network's website. Links to each are available in Chapter 11 of this plan, under the primary author's name.

Fort Wadsworth, Gateway National Recreation Area, Staten Island Unit, New York.

Reporting of monitoring results will also be phased in over time. As data are collected, annual reports of activities and findings for each monitoring protocol will be prepared (See Chapter 7). As data accumulate, reporting will be expanded to include comprehensive analysis and synthesis reports. Once the sixth year of monitoring is completed, reports will include trend assessments within park units and network-level summaries and comparisons.

Six additional protocols representing nine vital signs are in development and testing, and will be completed over the next three years. The expected completion dates for draft and final protocols, as well as additional key tasks associated with each monitoring project, are

Horseshoe crab (*Limulus polyphemus*), common in all Northeast Coastal and Barrier Network coastal parks.

summarized in the schedule below and detailed in Table 9.1.

In addition, Cape Cod NS is developing protocols as part of its Prototype Ecological Monitoring Program – see http://www1.nature.nps.gov/im/units/caco/ for additional information on the status of these protocols.

Monitoring Implementation Schedule

2005
- Draft protocols are completed for Ocean Shoreline Position, Estuarine Eutrophication, Salt Marsh Nekton and Salt Marsh Vegetation.

2006
- Peer review, revisions, and final protocols are completed, and monitoring begins for Ocean Shoreline Position, Estuarine Eutrophication, Salt Marsh Nekton and Salt Marsh Vegetation .
- Sampling design and methods are tested and draft monitoring protocols developed for Coastal Topography, Salt Marsh Elevation, Estuarine Nitrogen Loading, Visitor Use and Landscape Change.

2007
- Peer review, revisions and final protocols are completed for Coastal Topography, Salt Marsh Elevation, Estuarine Nitrogen Loading, Visitor Use and Landscape Change.
- Sampling design and methods are tested and draft monitoring protocols developed for Visitor Impacts.

2008
- Monitoring begins for Coastal Topography, Salt Marsh Elevation, Estuarine Nitrogen Loading, Visitor Use and Landscape Change.
- Peer review and the final protocol completed for Visitor Impacts.

2009
- Monitoring begins for Visitor Impacts

Table 9.1. Northeast Coastal and Barrier Network Vital Signs Monitoring Protocol Development and Implementation Schedule.

Protocol	Vital Signs	Draft Protocol	Peer Review	Final Protocol	Implementation
Shoreline Position*	Shoreline Position	October 2005	April 2006	August 2006	September 2006
Coastal Topography	Anthropogenic Modifications	October 2006	April 2007	October 2007	March 2008
	Offshore Topography				
	Marine Hydrography				
	Coastal Topography				
Salt Marsh Nekton *	Salt Marsh Nekton Community Structure	December 2004	January 2006	May 2006	June 2006
Salt Marsh Vegetation*	Salt Marsh Vegetation Community Structure	December 2004	January 2006	May 2006	June 2006
Salt Marsh Elevation	Salt Marsh Sediment Elevation	December 2006	June 2007	December 2007	June 2008
Estuarine Eutrophication*	Estuarine Sediment Chemistry	December 2004	October 2005	March 2006	June 2006
	Estuarine Water Chemistry				
	Estuarine Water Clarity				
	Estuarine Water Quality				
	Seagrass Condition				
	Seagrass Distribution				
Estuarine Nitrogen Loading	Estuarine Nitrogen Loading	December 2006	June 2007	December 2007	June 2008
Visitor Impacts	Visitor Impacts	December 2007	June 2008	December 2008	June 2009
Visitor Use	Visitor Use	December 2006	June 2007	December 2007	June 2008
Landscape Change	Landscape Change	December 2006	June 2007	December 2007	June 2008

(*Pilot monitoring began in 2005)

Chapter 10 Budget

The Stone House, Thomas Stone National Historic Site, Maryland.

This chapter presents the projected budget for the Northeast Coastal and Barrier Network monitoring program during the first year of operation. Projections are made according to the expense categories used in preparing the Inventory and Monitoring Program Annual Administrative Report and Work Plan, submitted to the National Program for National Resource Challenge reporting to Congress on an annual basis. The NCBN annual reports are available on the Network's website: http://www1.nature.nps.gov/im/units/ncbn.

Income

NCBN receives $776,500 from the NPS Servicewide Inventory and Monitoring Program for vital signs monitoring and $90,000 from the NPS Water Resources Division for water quality monitoring (see table 10.1). Final funding received by the Network can vary due to National and Regional assessments (cost of living increases and across the board cuts in funding).

Expenses

The annual expenses for the Network are listed in Table 10.1 and the percentage of the total budget devoted to each budget category is shown in Figure 10.1. The table shows expected costs, including fixed costs (such as staff and office facilities) and non-fixed costs (such as cooperative agreements, etc.) for the Network on an annual basis. In 2006 the Network will devote 55% of the budget to personnel costs for permanent, term, and seasonal NPS staff. This reflects the Network's commitment to maintaining a flexible staffing plan during the initial implementation of the monitoring program. Additional assistance with program implementation, protocol development and review, and data management will be provided through cooperative (or interagency) agreements with university partners and other federal partners. A total of 36% of the budget will be obligated to these agreements. The remaining 9% of the budget will be devoted to operations and equipment (5%) and travel (4%).

Adult Diamondback Terrapin (*Malaclemys terrapin*) female laying eggs, with nest excavated, Gateway National Recreation Area. (Photo taken by Don Riepe)

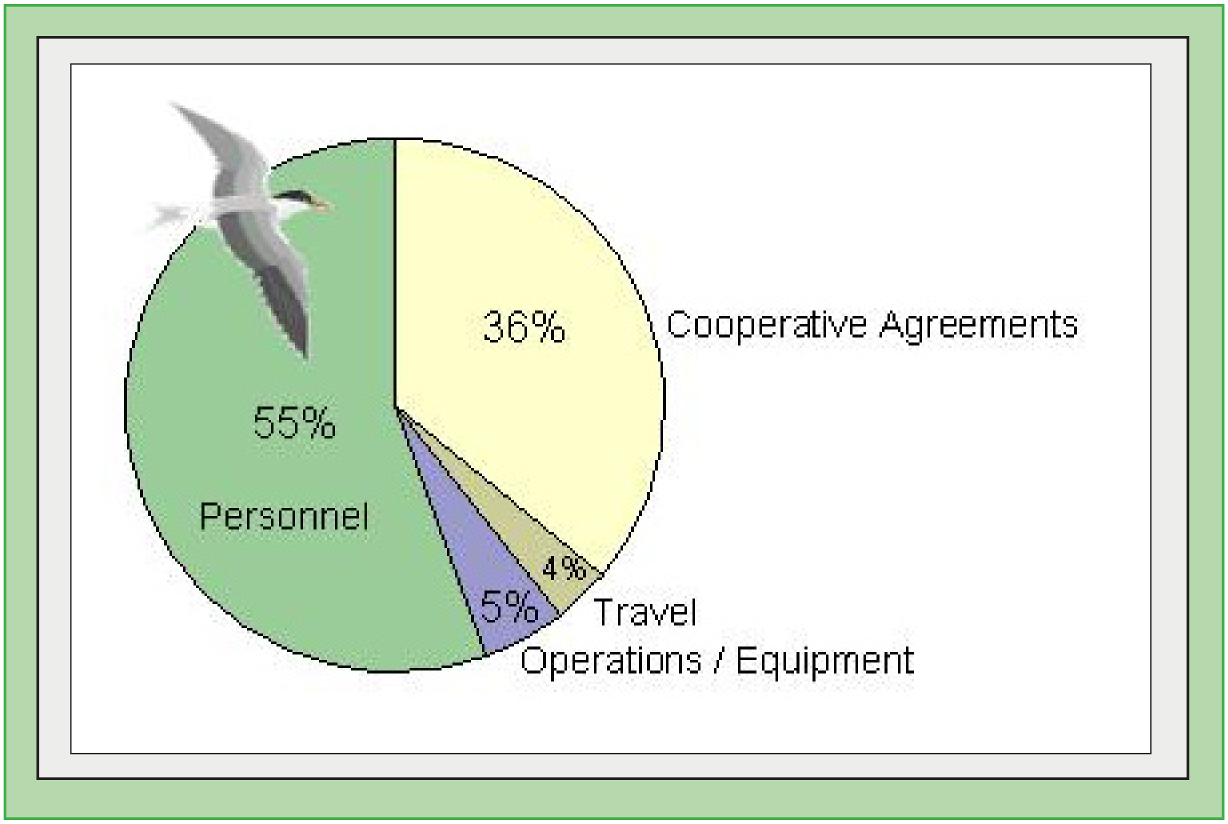

Figure 10.1. Northeast Coastal and Barrier Network Expenses (Percent) by budget category.

Wetland area at Thomas Stone National Historic Site, Maryland.

Fort Wadsworth, Gateway NRA, Staten Island Unitview of New York City.

Table 10.1. Annual income and proposed expenses for the Northeast Coastal and Barrier Network. The amounts devoted to each category are listed along with the funding sources (I&M Vital Signs or Water Resources Division Water Quality) and the types of payments (NPS, USGS (Interagency Agreement), CESU (Cooperative Agreement), Other (Non-CESU Cooperative Agreement or Contract).

Category	Amount	Source	Type
1. Income			
Vital Signs Monitoring	$778,000	I&M - VS $$	
Water Quality Monitoring	$90,000	WRD - WQ	
Total Income	**$868,000**		
2. Personnel			
Network Coordinator		I&M - VS $$	NPS
Biologist		I&M - VS $$	NPS
Data Manager		I&M - VS $$	NPS
Geographer/GIS Specialist		I&M - VS $$	NPS
Term Biologist		I&M - VS $$	NPS
Estuarine Eutrophication Monitoring		WRD - WQ	NPS
Salt Marsh Monitoring		I&M - VS $$	NPS
Sub Total	**$481,000**		
3. Cooperative Agreements			
Data Management Assistants		I&M - VS $$	CESU
Database Development and Archiving		I&M - VS $$	Other
Coastal Topography Monitoring		I&M - VS $$	CESU
Estuarine Eutrophication Monitoring		WRD - WQ	USGS
Estuarine Nitrogen Loading Monitoring		I&M - VS $$	CESU
Landscape Change Monitoring		I&M - VS $$	CESU
Ocean Shoreline Position Monitoring		I&M - VS $$	CESU
Salt Marsh Elevation Monitoring		I&M - VS $$	USGS
Salt Marsh Nekton Monitoring		I&M - VS $$	CESU
Salt Marsh Vegetation Monitoring		I&M - VS $$	CESU
Visitor Impact Monitoring		I&M - VS $$	Other
Visitor Use Monitoring		I&M - VS $$	Other
Sub Total	**$312,000**		
4. Operations / Equipment			
Boat Use		I&M - VS $$	NPS
Computer Equipment		I&M - VS $$	NPS
Estuarine Eutrophication Equipment & Supplies		WRD - WQ	NPS
Geomorphology Equipment & Supplies		I&M - VS $$	NPS
Office Equipment & Supplies		I&M - VS $$	NPS
Office Space and Logistical Support		I&M - VS $$	CESU
Salt Marsh Equipment & Supplies		I&M - VS $$	NPS
Vehicle Maintenance & Gasoline		I&M - VS $$	NPS
Sub Total	**$43,000**		
5. Travel			
Network Travel	$32,000		
Sub Total	**$32,000**		
Total Expenses	**$868,000**		

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Glossary

AARWP - Annual Administrative Report and Work Plan

ARD – Air Resources Division (NPS)

ASIS – Assateague Island National Seashore

Adaptive Management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form-"active" adaptive management-employs management programs that are designed to experimentally compare selected policies or practices, by implementing management actions explicitly designed to generate information useful for evaluating alternative hypotheses about the system being managed.

Agents of Change are the major external activities or processes that influence the natural system, which can be natural processes or human activities. In the NCBN general model, the agents of change are natural disturbance, land use, resource consumption, visitor and recreation use, and disasters.

Attributes are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem. The term Indicator is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). See Indicator.

Bathymetry is the measurement of water depths.

CACO - Cape Cod National Seashore

CESU – Cooperative Ecosystems Studies Unit

COLO – Colonial National Historical Park

DOI – Department Of the Interior

Ecological integrity is a concept that expresses the degree to which the physical, chemical, and biological components (including composition, structure, and process) of an ecosystem and their relationships are present, functioning, and capable of self-renewal. Ecological integrity implies the presence of appropriate species, populations and communities and the occurrence of ecological processes at appropriate rates and scales as well as the environmental conditions that support these taxa and processes.

Ecosystem is defined as, "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries" (Likens 1992).

Ecosystem drivers are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., earthquakes, droughts, floods) that have large scale influences on natural systems.

Ecosystem management is the process of land-use decision making and land-management practice that takes into account the full suite of organisms and processes that characterize and comprise the ecosystem. It is based on the best understanding currently available as to how the ecosystem works. Ecosystem management includes a primary goal to sustain ecosystem structure and function, a recognition that ecosystems are spatially and temporally dynamic, and acceptance of the dictum that ecosystem function depends on ecosystem structure and diversity. The whole-system focus of ecosystem management implies coordinated land-use decisions.

Ecosystem Responses are the measurable changes in ecosystem structure (biotic or physical), function, or processes.

Estuaries are aquatic environments in which ocean water and fresh water mix, including sub-tidal habitats and adjacent inter-tidal wetlands. Estuaries are usually semi-enclosed by land, and have open, partially obstructed, or sporadic access to the ocean.

Eutrophication is the process by which aquatic environments are altered through enrichment by mineral and organic nutrients, promoting a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the local reduction or extinction of other organisms.

FGDC - Federal Geographic Data Committee

FIIS – Fire Island National Seashore

Focal resources are park resources that, by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring regardless of current threats or whether they would be monitored as an indication of ecosystem integrity. Focal resources might include ecological processes such as deposition rates of nitrates and sulfates in certain parks, or they may be a species that is harvested, endemic, alien, or has protected status.

GATE – Gateway National Recreation Area

Geomorphology is the study of the shape and form of the landscape, and how the nature of landforms relates to their origin, development, and change over time.

GEWA – George Washington Birthplace National Monument

GIS – Geographic Information System

GMP – General Management Plan

GPS – Global Positioning System

GRD – Geologic Resources Division (NPS)

Hydrography is the science of the measurement, description and mapping of the surface waters of the earth.

I&M - Inventory and Monitoring, referring specifically to the National Park Service Inventory and Monitoring Program or related projects.

Indicators are a subset of monitoring attributes that are particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system.

Invasive Species are species that proliferate in an environment, dominating resources and/or displacing other species. This is generally used to mean species that display these tendencies following direct or indirect transport by humans to new environments.

LTEM – Long Term Ecological Monitoring. The Cape Cod National Seashore's monitoring program is one of several LTEM programs developed by prototype monitoring parks in the National Park system.

Lidar (LIDAR) – LIght Detection And Ranging. Lidar uses the same principle as RADAR. The lidar instrument transmits light out to a target. The transmitted light interacts with and is changed by the target. Some of this light is reflected / scattered back to the instrument where it is analyzed. The change in the properties of the light enables some property of the target to be determined. The time for the light to travel out to the target and back to the lidar is used to determine the range to the target. An airborne lidar platform is being tested for use as part of the NCBN Coastal Topography protocol.

Measures are the specific feature(s) used to quantify an indicator, as specified in a sampling protocol.

NASA - National Aeronautics and Space

Administration

NCBN – Northeast Coastal and Barrier Network

NER – Northeast Region (NPS)

NERO – Northeast Region Office (NPS)

NERRS - National Estuarine Research Reserve System

NHP – National Historic Park, as in Colonial NHP

NHS – National Historic Site, as in Sagamore Hill NHS

NM – National Monument, as in George Washington Birthplace NM

NOAA – National Oceanic and Atmospheric Administration, part of the U.S. Department of Commerce.

NPS - National Park Service

NRA – National Recreation Area, as in Gateway NRA

NS – National Seashore, as in Assateague Island NS

Nekton are all free swimming organisms in an aquatic environment. For the purposes of the Salt Marsh Nekton protocol, nekton are fish and decapod crustaceans in Network park salt marshes.

OMB – Office of Management and Budget

PAR – Photosynthetically Active Radiation

PDS – Protocol Development Summary

QA/QC – Quality Assurance / Quality Control

RMP – Resource Management Plan

SAHI – Sagamore Hill National Historic Site

SET - Surface Elevation Table: a portable mechanical leveling device for measuring the relative elevation of wetland sediments.

SOP – Standard Operating Procedure

Submerged Aquatic Vegetation (SAV) is the set of plant and seaweed (macroalgae) species that grow submerged in marine or estuarine habitats. Often used interchangeably with *seagrass*.

Sediment is matter deposited by a natural process, such as the movement of sand along beaches.

Stressors are physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level (Barrett et al. 1976:192). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include altered hydrology, altered landscape, invasive species, altered sediment and chemical inputs.

T & E – Threatened and Endangered

THST – Thomas Stone National Historic Site

USGS – United States Geologic Survey, a bureau of the Department of the Interior.

Vital Signs, as used by the National Park Service, are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

WASO – Washington Office (NPS)

WRD – Water Resources Division (NPS)

303(b) – Section 303(d) of The Clean Water Act, which requires that states develop an Impaired Waterbodies List for waterbodies that do not meet the water quality standards that the states have set. This list comprises two types of waters: first, those in which water quality standards cannot be met because of the presence of toxic pollutants; second, those in which certain uses cannot be maintained or achieved. These uses include public water supplies, agricultural and industrial uses, the protection and propagation of a balanced population of shellfish, fish and wildlife, and recreational activities in and on the water.

305(b) - Section 305(b) of the Clean Water Act, which requires each state to complete a Water Quality Report every two years identifying impairments for waters within each state. Waters listed in the 305(b) report are referred to as 305(b) listed waters and can be found on the EPA's Water Quality Inventory Electronic 305(b) Report website (http://www.epa.gov/waters/305b/index.html).

As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-24 October 2005

National Park Service
U.S. Department of the Interior

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Northeast Coastal and Barrier Network
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